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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 131.

B. T. GALLOWAY, *Chief of Bureau.*

MISCELLANEOUS PAPERS.

I. THE GERMINATION OF VEGETABLE SEEDS.
By EDGAR BROWN, *Botanist in Charge*, and WILLARD L. GOSS, *Assistant, Seed Laboratory.*

II. THE BOTANICAL HISTORY AND CLASSIFICATION OF ALFALFA.
By CARL S. SCOFIELD, *Agriculturist in Charge of Western Agricultural Extension Investigations.*

III. THE CROSS-INOCULATION OF FRUIT TREES AND SHRUBS WITH CROWN-GALL.
By GEORGE G. HEDGCOCK, *Scientific Assistant, Investigations of Diseases of Fruits.*

IV. RECENT STUDIES OF THE OLIVE-TUBERCLE ORGANISM.
By ERWIN F. SMITH, *Pathologist in Charge of the Laboratory of Plant Pathology.*

V. THE NECTARIES OF COTTON.
By FREDERICK J. TYLER, *Scientific Assistant, Fiber Plant Investigations.*

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[a] The five papers constituting this bulletin were issued in separate form on March 7, March 14, March 16, May 13, and July 6, 1908, respectively.

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MISCELLANEOUS PAPERS.

B. P. I.—351.

THE GERMINATION OF VEGETABLE SEEDS.

By Edgar Brown, *Botanist in Charge of Seed Laboratory*, and Willard L. Goss, *Assistant, Seed Laboratory*.

INTRODUCTION.

There is doubtless no more remunerative form of agricultural labor than that employed in caring for the kitchen garden, or home vegetable garden, and none which contributes so largely to the comfort and happiness of the family. From an educational standpoint the kitchen garden is even more important. It is here that country children have the opportunity to turn their exertions to practical use, and here that they first get an intimate acquaintance with plant life and its relations to agriculture.

On account of both the practical value of the kitchen garden and the stimulating effect it has on the children who care for it, the seeds that are sown should be the best. Most of these gardens are planted with seeds purchased in packets from the local store. These seeds, known in the trade as "commission" seeds, are put up in fancy-colored papers in display boxes and sent to local stores to be sold on commission, those unsold being returned at the end of the season. It is easy to see that this system may lead to abuse, and the results of an examination of a large number of samples of these seeds show that many seedsmen rely more on the striking appearance of the colored packets than on the quality of their contents.

GERMINATION TESTS.

During the spring of 1907 there were purchased in the States of Maine, Vermont, Massachusetts, Kentucky, Wisconsin, North Dakota, Kansas, and Colorado 2,778 packets of so-called "commission" vegetable seeds. These were put up by 27 seedsmen and included seeds of 26 kinds of vegetables. In Table I is shown the average germination of each kind of seed sold by each of these seed-packeting houses, as well as the average germination of each kind from all the houses, the average germination of all the kinds from each house, and the average germination of all the samples.

TABLE I.—*Average germination of "commission" vegetable seeds tested in 1907.*

[The figures in parentheses show the number of packets of seed tested in each case.]

Number assigned each seed-packeting house.	Bean.	Lima bean.	Cabbage.	Carrot.	Cauliflower.	Sweet corn.	Cress.	Cucumber.	Kale.	Kohl-rabi.	Leek.	Lettuce.	Muskmelon.
	P.ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P. ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P. ct.*	*P.ct.*
1	(1)	.....	(5)	(3)	.....	(2)	(1)	(4)	.....	.....	.....	(3)	.....
	36	.....	58.6	26	.....	75.5	0	56	.....	.....	.....	75.3	.....
2	(6)	(1)	(7)	(1)	(2)	(7)	.....	(3)	.....	.....	.....	(8)	(5)
	96.6	90	85.4	45	64.5	80.8	.....	81	.....	.....	.....	96.1	62.2
3	(2)	.....	(9)	(4)	.....	(2)	(1)	(6)	.....	.....	.....	(5)	(2)
	96.5	.....	46.3	52.2	.....	75	29	62.5	.....	.....	.....	76.4	31
4	(2)	.....	(4)	(1)	.....	.....	.....	(3)	.....	.....	.....	(2)	.....
	98	.....	46.2	55	.....	.....	.....	73.3	.....	.....	.....	73	.....
5	.....	.....	(2)	(1)	.....	.....	(1)	(4)	.....	.....	.....	(2)	.....
	.....	.....	55.5	64	.....	.....	98	79	.....	.....	.....	73.5	.....
6	(8)	.....	(34)	(10)	(2)	(1)	(2)	(12)	(3)	(2)	(2)	(21)	(11)
	67.6	.....	21.8	30.1	26	63	45	65.8	22.7	4	12	72.3	28.9
7	.....	.....	(11)	(4)	(1)	.....	.....	(7)	.....	.....	.....	(9)	(4)
	.....	.....	67.1	54.7	69	.....	.....	76	.....	.....	.....	88.7	74.5
8	(6)	(1)	(18)	(3)	(1)	(4)	.....	(9)	(1)	(2)	(2)	(9)	(2)
	89.9	100	33.2	26	60	56	.....	70.2	0	63.5	54	66.8	17
9	.....	.....	(8)	(5)	.....	.....	(2)	(17)	(1)	.....	(2)	(13)	(2)
	.....	.....	31.5	21.6	.....	.....	87.5	66.2	59	.....	51	73.4	64
10	.....	.....	(7)	(2)	.....	.....	(1)	(7)	.....	.....	.....	(5)	(2)
	.....	.....	75.4	56	.....	.....	79	90.7	.....	.....	.....	77.8	86
11	(13)	(1)	(77)	(35)	(9)	(3)	.....	(41)	(9)	(5)	(7)	(51)	(25)
	92.4	75	73.1	57.6	73	85.3	.....	67.4	60.3	71	47.8	88.5	78.8
12	(2)	(1)	.....	.....	.....	(1)	.....	(1)	.....	.....	.....	(3)	(1)
	98.5	96	.....	.....	.....	95	.....	96	.....	.....	.....	95.3	82
13	(2)	.....	(1)	(1)	(2)	(2)	.....	(3)	.....	(1)	.....	(3)	(2)
	73.5	.....	90	87	53.5	76.5	.....	83	.....	97	.....	82	88
14	.....	.....	(4)	(2)	.....	.....	(1)	(4)	(1)	(1)	.....	(6)	(3)
	.....	.....	30	41.5	.....	.....	64	44.5	13	45	.....	42.5	31
15	.....	.....	(6)	(4)	.....	.....	(1)	(8)	.....	.....	.....	(5)	(2)
	.....	.....	53	49.2	.....	.....	44	72.1	.....	.....	.....	79.4	37.5
16	(16)	(4)	(32)	(9)	(5)	(17)	.....	(21)	(2)	(1)	(2)	(20)	(6)
	80.6	91.2	32.5	30.9	47.6	55.8	.....	70.3	47.5	3	17.5	71.9	42.2
17	(5)	.....	(12)	(8)	.....	(5)	.....	(13)	.....	(2)	(2)	(14)	(5)
	60.8	.....	12.5	25.4	.....	84.2	.....	55.1	.....	39	22	42	47
18	.....	.....	(1)	.....	(1)	.....	.....	(1)	.....	.....	.....	(1)	.....
	.....	.....	10	.....	0	.....	.....	95	.....	.....	.....	60	.....
19	.....	.....	(6)	(3)	(2)	.....	(1)	(6)	(3)	(1)	(1)	(6)	(3)
	.....	.....	63.5	42.7	75.5	.....	94	85.2	46.6	76	50	91.3	60.7
20	(3)	(1)	(4)	.....	.....	.....	.....	(3)	.....	.....	.....	(2)	.....
	95.3	95	63.2	.....	.....	.....	.....	81	.....	.....	.....	75.5	.....
21	(2)	.....	(6)	(4)	.....	(4)	(1)	(5)	(1)	(1)	(1)	(3)	(2)
	95.5	.....	65.5	45.2	.....	72.5	98	83.6	66	91	72	98	93
22	(3)	.....	(1)	(4)	.....	.....	.....	(1)	.....	.....	.....	(6)	(1)
	93.7	.....	71	44	.....	.....	.....	85	.....	.....	.....	68.2	97
23	.....	.....	(5)	(3)	.....	.....	.....	(6)	.....	.....	.....	(6)	(1)
	.....	.....	62.4	58.3	.....	.....	.....	74.2	.....	.....	.....	90.2	90
24	(18)	(1)	(58)	(20)	(5)	(12)	(2)	(39)	.....	.....	.....	(40)	(16)
	87.2	94	47	48.1	52.8	81.8	52.5	60.3	.....	.....	.....	71.5	61.5
25	.....	.....	(11)	(6)	.....	.....	(2)	(11)	.....	.....	.....	(10)	(2)
	.....	.....	66.3	54.8	.....	.....	86	79.8	.....	.....	.....	90.5	53
26	.....	.....	(1)	.....	.....	.....	.....	(4)	.....	.....	.....	(3)	.....
	.....	.....	80	.....	.....	.....	.....	76.7	.....	.....	.....	66	.....
27	(9)	(1)	(1)	(2)	(1)	(5)	.....	(5)	.....	(1)	.....	(4)	.....
	81.1	92	81	69.5	85	83.6	.....	86.4	.....	84	.....	82.2	.....
Average of each kind for all packeting houses	(98)	(11)	(331)	(135)	(31)	(65)	(16)	(244)	(21)	(11)	(19)	(260)	(97)
	84.9	91.5	50.8	45.4	56.3	73.9	65.5	69.7	46.9	56	40.5	76.7	61.1

TABLE I.—*Average germination of "commission" vegetable seeds tested in 1907*—Cont'd.

[The figures in parentheses show the number of packets of seed tested in each case.]

Number assigned each seed-packeting house.	Onion.	Parsnip.	Pea.	Pepper.	Pumpkin.	Radish.	Ruta-baga.	Salsify.	Spinach.	Squash.	Tomato.	Turnip.	Watermelon.	Average of all kinds for each packeting house.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
1	(2) 42.5	(2) 1	(2) 65	....	(1) 8	(2) 78.5	(3) 52	....	(1) 54	(5) 34.6	(2) 64	(3) 33.7	....	(42) 47.7
2	(3) 64	....	(4) 94.2	(3) 81.3	(6) 73.7	(3) 87	(1) 98	(2) 42	....	(6) 88.5	(6) 83.8	(2) 96.5	(5) 72.4	(81) 81.7
3	(4) 28.5	(1) 6	(1) 80	....	....	(8) 69.2	(2) 44	(1) 2	(1) 44	(3) 60.3	(2) 57	(2) 58.5	(2) 64	(58) 55.9
4	(1) 15	(1) 4	(3) 70.3	....	....	(2) 75	....	....	....	....	(2) 87	(1) 99	....	(22) 68
5	(1) 65	(1) 75	....	....	(1) 84	(1) 98	(1) 75	(1) 0	....	(1) 60	(2) 86	....	....	(19) 71.8
6	(14) 12.8	(4) 1.2	(1) 84	(6) 27	....	(32) 50.1	(7) 21	(4) 17.5	(2) 65.5	(19) 55.7	(10) 78.8	(15) 68.6	(19) 47.3	(241) 44.3
7	(4) 61	(1) 16	....	....	....	(5) 70.8	(3) 89	....	(2) 79.5	(7) 83.7	(8) 64.4	(3) 85.7	(3) 78.5	(72) 73.4
8	(5) 26	(7) 7.3	(5) 83.2	....	....	(16) 73	(2) 11	(1) 0	(1) 43	(5) 22	(8) 52.6	(5) 39.6	(2) 48	(115) 50
9	(4) 55	(2) 10.5	....	....	....	(11) 66	(4) 55	....	....	(8) 68.6	(5) 67.6	(4) 80.7	(3) 72.8	(91) 60.6
10	(2) 35	(2) 15.5	....	....	(1) 84	(4) 94	....	....	....	(4) 69.2	(3) 83.7	(1) 29	(2) 85.5	(43) 75
11	(33) 74.3	(17) 30.7	(10) 88.1	(10) 30.3	....	(56) 79.9	(8) 93.1	(9) 43.2	(5) 76	(36) 66.5	(49) 77.7	(44) 92.7	(45) 74.4	(598) 73.7
12	....	(1) 38	(2) 83	....	....	(5) 60.6	....	....	(1) 51	(4) 78.7	....	(1) 95	....	(23) 79.1
13	....	....	(3) 60.7	(1) 71	(2) 76	(4) 78	....	....	....	(1) 90	....	(1) 79	(2) 91	(31) 78.1
14	(3) 59.7	(2) 29.5	....	(1) 47	....	(5) 66.2	(3) 31.6	....	(2) 63.5	(3) 42	(3) 49.3	(4) 77.7	(3) 15.3	(51) 45.5
15	(2) 85	(1) 66	....	....	....	(6) 94	(1) 41	(1) 15	(1) 78	(5) 72	(4) 77	(3) 81.7	(3) 64	(53) 68.8
16	(10) 25.7	(7) 6.1	(14) 56.8	(2) 43.5	(6) 55.9	(27) 69.5	(2) 24.5	(2) 48.5	(1) 12	(15) 64.7	(16) 56.6	(12) 26	(5) 46.4	(259) 53
17	(4) 8.5	(2) 26.5	....	(3) 3	....	(13) 52.4	(3) 24.6	(2) 1	(2) 39.5	(9) 27.8	(6) 49.5	(7) 27.8	(4) 25.5	(121) 37.3
18	(1) 74	(1) 36	....	(1) 32	(1) 72	....	....	(1) 6	....	....	(1) 89	....	(1) 76	(11) 50
19	(5) 73.8	(1) 2	....	(2) 3.5	....	(9) 90.5	(2) 81	(1) 14	(1) 66	(2) 18	(4) 83	(3) 92	(5) 63.6	(67) 69.5
20	(2) 76.5	....	....	....	....	....	....	....	....	(1) 82	....	(2) 59.5	....	(18) 76.8
21	(6) 52.7	(2) 46.5	(3) 94.6	(2) 9.5	....	(6) 92.7	(1) 91	(1) 72	....	(2) 84	(4) 77.5	(2) 100	(2) 89.5	(61) 74.9
22	(4) 3.7	(1) 13	(1) 72	(1) 31	....	(1) 96	(1) 18	(1) 29	....	(1) 0	(1) 84	(1) 75	(1) 86	(30) 54.6
23	(4) 50	(1) 59	....	(1) 36	(1) 32	(10) 92.9	(1) 78	(1) 77	(1) 82	(2) 44	(1) 79	(2) 77.5	(1) 68	(47) 73.3
24	(21) 38.1	(8) 18.2	(18) 77.2	(12) 33	....	(50) 64.7	(9) 81.6	(6) 19	(2) 64	(39) 53.9	(27) 58.2	(43) 62.8	(24) 58.8	(470) 58.8
25	(4) 22.3	(2) 26.5	....	....	(2) 79	(8) 67.9	(1) 71	....	(2) 63	(8) 76.3	(5) 53.2	(7) 72.1	(2) 90	(83) 68.9
26	(1) 49	(1) 0	....	....	....	(7) 61.3	....	....	....	....	(2) 61.5	(2) 97	....	(21) 65.7
27	(1) 75	(1) 42	(4) 95	(2) 60	....	(2) 80	(1) 99	(1) 4	(1) 65	(3) 71.7	(2) 96.5	(3) 64.3	....	(50) 78.7
Average of each kind for all packeting houses.	(141) 45	(69) 20.8	(76) 74.4	(47) 33.7	(21) 63.9	(293) 71.3	(56) 58.6	(35) 27	(26) 62	(189) 59.8	(173) 69	(173) 69.9	(134) 64	(2,778) 62.2

The germination of many kinds of seed was surprisingly low. The average germination of the 135 samples of carrot seed tested was 45.4 per cent; of the 141 samples of onion seed, 45 per cent; of the 331 samples of cabbage seed, 40.8 per cent; of the 47 samples of pepper seed, 33.7 per cent; of the 35 samples of salsify seed, 27 per cent; while of the 69 samples of parsnip seed, only 20.8 per cent germinated.

The seed from certain packeting houses was especially poor. Of 121 packets put up by one seedsman, the average germination was only 37.3 per cent, and of 241 packets put up by another the average germination was 44.3 per cent. In many cases wide differences in germination were found between different packets from the same seedsman, as shown in Table II.

TABLE II.—*Comparison of the highest and lowest percentages of germination of lettuce seed packeted by several firms for sale on commission.*

Number assigned each seed-packeting house.	Highest germination.	Lowest germination.	Difference.	Number assigned each seed-packeting house.	Highest germination.	Lowest germination.	Difference.
	Per cent.	*Per cent.*	*Per cent.*		*Per cent.*	*Per cent.*	*Per cent.*
6	95	5	90	16	99	0	99
8	99	2	97	17	89	0	89
9	100	17	83	22	100	2	98
11	100	20	80	24	100	19	81

Of 200 packets from 21 of the 27 packeting houses referred to, none germinated more than 10 per cent, while all the seed in 62 packets from 13 firms failed to germinate.

It is evident that some seedsmen are not ignorant of the quality of the seed they are selling. In the case of one firm, whose packets bear private distinguishing marks, the following differences in the average germination were found between packets bearing one mark and those bearing another mark:

TABLE III.—*Variation in germination of "commission" vegetable seed put up by one seed-packeting house.*

Kind of seed.	Packets bearing private mark No. 1.		Packets bearing private mark No. 2.		Difference in average germination.
	Number tested.	Average germination.	Number tested.	Average germination.	
		Per cent.		*Per cent.*	*Per cent.*
Lettuce	27	97	24	79	18
Cabbage	28	87	49	65	22

"COMMISSION" SEEDS COMPARED WITH THOSE SENT OUT IN THE CONGRESSIONAL SEED DISTRIBUTION.

In view of some criticisms of the quality of the seeds sent out in the Congressional seed distribution, the following table (Table IV) is

presented, showing the average germination of the various kinds of commission seeds tested in comparison with the average germination of the same kinds of seeds distributed by the Department of Agriculture on Congressional orders during the past six years.

TABLE IV.—*Comparison of "commission" seeds with those sent out in the Congressional seed distribution.*

Kind of seed.	Average germination for six years of seeds sent out on Congressional orders.	Average germination of "commission" seeds tested.	Difference.	Kind of seed.	Average germination for six years of seeds sent out on Congressional orders.	Average germination of "commission" seeds tested.	Difference.
	Per cent.	*Per cent.*	*Per cent.*		*Per cent.*	*Per cent.*	*Per cent.*
Beans	96	84.4	11.6	Pea	93	74.4	18.6
Lima beans	96	91.5	4.5	Pepper	67	33.7	33.3
Cabbage	88	50.8	37.2	Radish	96	71.3	24.7
Carrot	75	45.4	29.6	Spinach	83	62	21
Sweet corn	86	73.9	12.1	Squash	92	59.8	32.2
Cucumber	89	69.7	19.3	Tomato	86	69	17
Kale	85	46.9	38.1	Turnip	94	69.9	24.1
Lettuce	95	76.7	18.3	Watermelon	87	64	23
Muskmelon	89	61.1	27.9				
Onion	86	45	41	General average	87.3	61.6	25.7
Parsnip	77	20.8	56.2				

In all cases the average germination of the "commission" seeds tested was lower than that of those sent out in the Congressional seed distribution, varying from 4.5 per cent for Lima beans to 56.2 per cent for parsnips.

That many firms are selling vegetable seeds not only of a low average quality but often entirely worthless makes it evident that some sort of protection should be afforded the purchaser by a guaranty of quality given by the seedsman.

SUMMARY.

"Commission" seeds are largely used in planting kitchen gardens, and should be of good quality.

The quality of such seeds is poor, the average germination of 2,778 packets of 26 kinds from 27 seed-packeting houses being only 62.2 per cent.

The average germination of seeds from one firm was only 37.3 per cent, and from another 44.3 per cent.

The variation in germination of different packets of the same kind of seed from the same firm was in several cases more than 90 per cent.

By 21 of the 27 seedsmen whose seed was tested, 200 lots of seed were put up which germinated 10 per cent or less.

By 13 packeting houses 62 lots of seed were put up which entirely failed to germinate.

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The average germination of the "commission" seeds tested was 25.7 per cent lower than that of those sent out in the Congressional seed distribution during the past six years.

The purchaser should receive some sort of guaranty as to the quality of the seeds he is buying.

B. P. I.—348.

THE BOTANICAL HISTORY AND CLASSIFICATION OF ALFALFA.

By Carl S. Scofield, *Agriculturist in Charge of Western Agricultural Extension Investigations.*

INTRODUCTION.

The genus of plants to which alfalfa belongs contains a large number of species and is of great agricultural importance, since it includes, besides alfalfa, a number of promising species as yet little known. The genus includes two groups of species that are very distinct from an agricultural standpoint. The first and more important is the group of erect perennials of the alfalfa type. The other consists of species that are prostrate or spreading in habit of growth; nearly all of these are annuals. This latter group includes the so-called bur clovers, which are valuable as range plants in the West and Southwest and are used also for early spring pasture along the coast of the Gulf of Mexico.

During a trip made by the writer to Algeria in the spring of 1901, opportunity was afforded for a comparative study of some of the species of this genus, a large number of which are indigenous to North Africa. In attempting to identify the various Algerian species, the literature of the group has been examined, and as a result it seems certain that a complete revision will be necessary before these species can be correctly identified and their relationships properly understood. Such a revision is now in progress, but since its early completion is not practicable and since it will necessitate a change in the botanical name of alfalfa, it seems proper to give a brief statement regarding the botanical history and classification of that plant.

THE ORIGIN OF THE ALFALFA PLANT AND OF ITS COMMON NAMES.

The forage plant popularly known in America as alfalfa, or lucern, is generally believed to be of Asiatic origin, but the record of the first domestication and earliest use of the plant is vague. It was apparently well established in agriculture before the earliest records of Greek history, but whether it was first domesticated by the Persians,

as the Greeks supposed, or was used earlier by people farther east is not known.

As is the case with many other domesticated plants, there is much uncertainty as to the identity of the wild species from which the present cultivated species is descended. In fact, the botanical name was first given to the domesticated plant and has never been associated with any wild species.

The early Persian name[a] of the plant has not come down to us, but the Romans, who learned of it and its culture from the Greeks, accepted both the Greek name and the account of the introduction of the plant into Greece from Persia, which is said to have occurred at the time of the Persian invasion, about 490 B. C. Thus the names "Medike," by which the plant was known to the Greeks, and "Herba Medica," by which it was known to the Romans, refer to its Persian or Median origin. It was highly prized as a forage crop, especially by the Romans, and is frequently mentioned by their writers on agriculture and natural history as early as the beginning of the Christian era. Some time early in the Middle Ages it came to be known popularly under the name "luzerne" (spelled also "luserne," "lucerne," and "lucern"), which was probably derived from the name of a river valley in northern Italy, in the western Piedmont country.[b]

Alfalfa was undoubtedly known and cultivated as a forage plant in northern Africa nearly or quite as early as it was known in Italy, but whether the culture was carried into Africa by the Romans or whether it was brought westward direct from Asia is not clear. The Arab invasion which swept across northern Africa and into southwestern Europe in the seventh century seems to have carried the culture of the plant and the Arabic name with it into Spain, so that at about the time the southern Europeans were beginning to know the plant as "luzerne" the North African and Spanish people, under Arabic and Moorish influence, were calling it by the name "alfalfa," or "alfacfacah," which in the Arabic language means "the best kind of fodder."

With the discovery and colonization of America the English and West European colonists brought the plant and the name "lucern" to eastern North America, while the Spanish colonists carried the same plant, under the name "alfalfa," to Mexico and South America.

[a] There is some difference of opinion as to what was the prevailing Persian name, but the most generally accepted view is that it was "aspest," signifying "horse fodder."

[b] De Candolle, in his Origin of Cultivated Plants, 2d ed., 1886, p. 103, prefers to trace the derivation of the name "lucern" from an old Spanish name, *eruye*, thence through the Catalonian name *userdas* to "the patois name in the south of France, *laouzerdo*, nearly akin to *luzerne*." This evidence, however, does not seem sufficient to justify the acceptance of the more devious rather than the more direct derivation.

Until very recently the name "lucern" has been the more popular in the eastern United States, and it was even carried as far west as Utah by the Mormon pioneers in the middle of the nineteenth century, where it still persists in common use.

The culture of the plant from the European introduction did not prosper in the eastern United States and it has never secured a very important place in eastern agriculture. It was found to be well adapted to many places in Central and South America, however, and its culture and the name "alfalfa" spread together very rapidly throughout that part of the hemisphere. The plant was also carried northward by Spanish settlers along the Pacific coast to California, where it has become the most important forage plant of the region. More recently it has been spread through the Eastern States again, until now it is known and cultivated to some extent in every State in the Union, and at the present time the Arabic-Spanish name alfalfa has almost entirely replaced the European name lucern.

THE EARLY SCIENTIFIC NAME.

The history of the technical name of alfalfa is much more complicated than that of the common name. The earliest botanists apparently accepted the common Latin name "Medica" for the plant, and when similar and apparently related plants were discovered the same name was given them, with the addition of other distinguishing and descriptive terms, according to the custom that prevailed previous to the promulgation of the binomial system of nomenclature by Linnæus in 1753. In the year 1700 Tournefort, the noted French botanist, published in his Institutiones Rei Herbariæ, under the group name Medica, a list of these descriptive names for alfalfa and its related species. Two of these species were illustrated in the upper half of plate 231, a reproduction of which is shown in figure 1. In the same work is described a plant, a native of southern Europe, to which the name Medicago is given, because, as Tournefort said, it resembles Medica,[a] and this plant is illustrated in the lower half of the plate mentioned.

THE CONFUSION OF GENERIC NAMES.

In the first edition of his Systema Naturæ, published in 1735, Linnæus, following the earlier writers, applied the name Medica to alfalfa and its related species, and as he then evidently regarded the Medicago of Tournefort as congeneric with alfalfa he used the name Medicago as a synonym of Medica. In his Species Plantarum, published in 1753, the standing of these names was reversed without

[a] "Medicago, id est planta ad Medicam accedens." Tournefort, 1700, Inst. Herb., p. 412, pl. 231.

comment or explanation, the name Medicago being applied to the genus and the name Medica being reduced to a synonym.[a] Alfalfa

FIG. 1.—Tournefort's plate 231, illustrating flowers, fruits, and seeds of Medica and Medicago. (This illustration is cited by Linnæus in his Genera Plantarum, 1754, as the basis of the genus Medicago.)

was given the name *Medicago sativa*, and the species described and figured by Tournefort under the name Medicago was called

[a] It is quite probable that Linnæus made this change of name to avoid the use of a simple adjective as a generic name.

Medicago radiata. Practically all botanists since have followed the classification of Linnæus so far as alfalfa is concerned, and alfalfa is now generally known by its Linnæan name, *Medicago sativa*.

THE TYPE OF THE GENUS MEDICAGO.

The generic name Medicago as used by Linnæus, when typified according to the accepted rules of nomenclature, is based on the Medicago of Tournefort, which is the *Medicago radiata* of Linnæus. This plant can not properly be regarded as congeneric with alfalfa. The similarity noted by Tournefort and accepted by Linnæus is merely superficial. This fact becomes apparent if the seeds of the two species are compared (see fig. 2, *a* and *c*). Since *Medicago radiata* is comparatively rare and little known, the great dissimilarity between it and alfalfa was not appreciated by botanists until 1841, when Trautvetter attempted to remedy matters by transferring *Medicago radiata* to the genus Pocockia. This was done apparently without knowledge of, or at least without considering, the fact that the name Medicago was first given to this species and that it was therefore the type of the genus.

The genus Pocockia was erected by Scringe in 1825,[a] but was reduced from generic rank by Bentham and Hooker in 1865.[b] The name has since been applied to a section of the genus Trigonella. The new binomial, *Trigonella radiata*, was published by Boissier in 1872,[c] since which date the type of the genus Medicago has not been included in that genus.

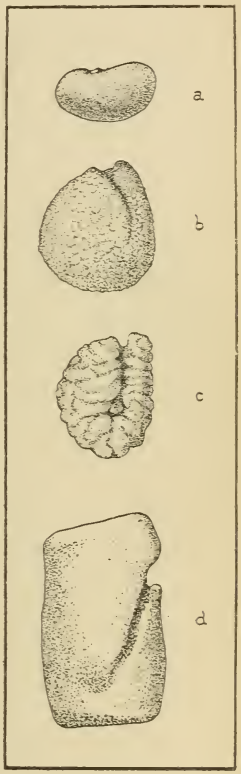

FIG. 2.—Seeds typical of alfalfa and related genera; *a*, seed of alfalfa, *Medica sativa*; *b*, bur clover, *Medicago orbicularis*; *c*, *Medicago radiata*; *d*, *Trigonella foenum-graecum*. (Magnified 6 diameters.)

THE TYPE OF THE GENUS MEDICA.

Since the name Medicago can not properly be applied to alfalfa, it remains to trace out the proper generic name. The earliest post-Linnæan author to treat of this group of plants is Dr. John Hill, whose British Herbal was published in 1756.

[a] De Candolle, 1825, Prod. Syst. Nat. Veg., vol. 2, p. 185.
[b] Bentham and Hooker, 1865, Genera Plantarum, vol. 1, p. 487.
[c] Boissier, 1872, Fl. Orient., vol. 2, p. 90.

Hill used the name Medica[a] for the genus, and referred to the earlier publication by Linnæus, saying, "He alters the name, writing it Medicago." While Hill did not use the binomial system of nomenclature, his first species is associable by citation with a previously published binomial. The species which Hill calls *Medica sylvestris flore flavo*, the "Yellow Medick, with flat, wreathed pods," is without doubt the *Medicago falcata* of Linnæus. It is listed by Hill as the first of the British species, and is also the first of the several species illustrated on the plate cited. Hill's citation for this species is: "C. Bauhine calls it *Trifolium luteum sylvestre lignea sive frutescens.*" Linnæus's citation[b] under the name *Medicago falcata* is given in slightly different form, "*Trifolium sylvestre luteum, siliqua cornuta. Bauh. pin.* 330": but it can apply to no other of Bauhin's species. The exact wording of Bauhin's description is[c] "*Trifolium syl. luteum siliqua cornuta, vel Medica frutescens.*" It seems proper, therefore, to credit Hill with the first post-Linnæan publication of the generic name Medica and to treat the *Medicago falcata* of Linnæus as the type of the genus.

Adanson[d] also used the name Medica rather than Medicago, making Medicago a synonym. This author, however, was dealing only with families and genera, and did not enumerate the species of Medica.

The first publication in which the name Medica was used in direct connection with binomial species is the eighth edition of the Gardener's Dictionary, by Philip Miller.[e] This author, like Hill, called attention to the change of names by Linnæus, and said:

> This genus of plants is ranged in the third section of Linnæus's seventeenth class, which includes the herbs with a buttertly flower, having ten stamina in two houses. He also has joined the Medica and Medicago of Tournefort together, making them one genus under the title Medicago, but Tournefort makes the distinguishing character of Medicago to consist in having a falcated compressed pod. Therefore I shall here separate those plants whose pods are of that form from the others whose pods are twisted like a screw; and as the title of Medica was first applied to the Lucern, so I shall continue it to those species as have such pods, and refer the others to the genus of Medicago.

Notwithstanding his evident appreciation of the generic differences recognized by Tournefort, Miller proceeded to complicate the situation still more in his distribution of species to the two genera. In the genus Medica he lists in the following order: *Medica sativa, Medica falcata, Medica radiata, Medica hispanica, Medica italica,*

[a] Hill, 1756. British Herbal, p. 311, pl. 45.
[b] Linnæus, 1753. Species Plantarum, vol. 2, p. 779.
[c] Bauhin, 1623. Pin., p. 330.
[d] Adanson, 1763. Familles des Plantes, p. 325.
[e] Miller, 1768. Gardener's Dictionary, not paged.

Medica cretica, and *Medica arborea*. The first species has "pods that are twisted like a screw," while the others, with the possible exception of *Medica italica*, of which the identity is in doubt, have "falcated compressed" pods. Furthermore, his *Medica falcata* and *Medica arborea* are certainly congeneric with *Medica sativa*, while his *Medica radiata* and *Medica cretica* are species of true Medicago. His *Medica hispanica*, the *Medicago circinnata* of Linnæus, is now known as *Circinus circinatus* (L.) Kuntze.

In the genus Medicago, Miller lists the following species: *Medicago marina*, *Medicago scutellata*, *Medicago tornato* (sic), *Medicago intortexta* (sic), and *Medicago laciniata*, all of which have "pods that are twisted like a screw" instead of "a falcated compressed pod." This grouping of the species was both illogical and incorrect and may have been in part the reason that later botanists chose to follow Linnæus rather than Miller in the use of these names.

It will be seen from the foregoing that the generic name Medica as used by Hill is based on the plant known as *Medicago falcata* L. This Linnæan name is not valid because, as will be shown later, that plant is not congeneric with the type of the genus Medicago. Hill must be recognized, therefore, as the author of the genus name Medica and Miller as the author of *Medica falcata*, the name of the type of that genus, and of *Medica sativa*, the correct name of alfalfa.

THE SEED CHARACTERS OF ALFALFA AND RELATED GENERA.

The seed characters of Medica and the related genera are sufficiently distinct and striking to aid materially in understanding the generic differences. The seed of *Medica sativa*, which is the best known species of the genus Medica, is shown in figure 2, *a*. It is kidney shaped, 2 mm. to 2.5 mm. long, with considerable variation in outline. The seed coat is nearly or quite smooth, with the radicle extending half the length of the cotyledons, or a little more, and with the line between the radicle and the cotyledons scarcely distinguishable. There is also considerable variation in the color, which ranges from a dull yellow, sometimes tinged with green, to a reddish brown.

The seed of the type species, *Medica falcata*, is similar to that of *Medica sativa*, but is slightly larger, averaging nearly 2.5 mm. in length. The radicle is proportionately longer and more distinct, and the color is usually brighter, ranging from a pale yellow to light brown.

The seed of *Medicago radiata* (fig. 2, *c*) is slightly less than 3 mm. long, dark reddish brown in color, the radicle equaling or even exceeding the cotyledons in length, and the seed coat is very rough and transversely wrinkled even when the seed is plump. It may be

observed that the seed of this species is well illustrated in Tournefort's plate (see fig. 1).

It should be noted in this connection that the seed of *Medicago orbicularis* (fig. 2, *b*) resembles that of *Medicago radiata* rather than that of *Medica sativa*. This species, *Medicago orbicularis*, is the only true Medicago which has not been transferred by botanists to another genus. This is probably due to the fact that in general appearance and habit of growth this species is not sufficiently different from some of the other so-called "bur clovers" to attract attention. A close examination of the seed, however, leaves no doubt that this species is congeneric with *Medicago radiata* rather than with *Medica falcata*.

Since the *Medicago radiata* of Linnæus has been placed by all recent botanists in the genus Trigonella, a seed of *Trigonella foenum-graecum*, the type of that genus, is also shown (fig. 2, *d*). The seed of this species is relatively large, 4 to 5 mm. long, subcylindric, obliquely truncate in outline, dull yellow to brownish red in color, with the seed coat nearly smooth and the radicle very prominent and about two-thirds as long as the cotyledons.

The seeds of these three groups are thus seen to be strikingly different, and so far as known there are no intergradations between them with respect to these characters. In view of these facts it seems necessary to recognize three genera to include the species hitherto grouped under the generic names Medicago and Trigonella.

ANALYTICAL KEY TO THE GENERA.

Pod cylindrical, straight or hooked, with a long, attenuated beak; seeds subcylindric or compressed, the ends obliquely truncate by mutual pressure. Genus *Trigonella* (Tournefort) Linnæus; type, *T. foenum-graecum* Linnæus.

Pod flattened, sickle shaped or twisted into a spiral, abruptly short pointed; seed kidney shaped or orbicular.

- Seed kidney shaped, about twice as long as broad, the surface smooth; radicle about half the length of the cotyledons. Genus *Medica* (Tournefort) Hill; type, *M. falcata* (Linnæus) Miller.
- Seed suborbicular or oval, very little longer than broad; surface rough, punctate, tuberculate, or wrinkled; radicle as long as or longer than the cotyledons. Genus *Medicago* (Tournefort) Linnæus; type, *M. radiata* Linnæus.

SUMMARY.

Alfalfa has been cultivated as a forage crop since very ancient times. It was brought into Greece by the Persians about 490 B. C. Its culture spread westward on both sides of the Mediterranean and later to both American continents, where it is now widely distributed. It was known to the Greeks and Romans as "Medike" and "Herba Medica" on account of its supposed Median origin. Its common

English and European name, lucern, is probably derived from the name of the valley of the Luzerne River, in northern Italy. Its common Spanish and American name, alfalfa, is derived from an Arabic word, "alfacfacah," meaning "the best kind of fodder."

The prevalent botanical name of alfalfa, *Medicago sativa*, can not properly be used for this plant, since the name Medicago belongs to another plant not congeneric with alfalfa. The plant which was described under the name Medicago and to which that name properly belongs has been recently known to a majority of botanists as *Trigonella radiata*. The correct botanical name of alfalfa is *Medica sativa* (L.) Mill.

B. P. I.—350.

THE CROSS-INOCULATION OF FRUIT TREES AND SHRUBS WITH CROWN-GALL.[a]

By George G. Hedgcock, *Scientific Assistant, Investigations of Diseases of Fruits.*

INTRODUCTION.

In another publication[b] brief mention has been made by the writer of the identity of the forms of disease known as crown-gall occurring upon the almond, apricot, blackberry, cherry, peach, plum, prune, chestnut, and walnut. This identity has been fully established by subsequent experiments with nearly 5,000 seedlings grown in sterilized soil, watered with sterile water, and inoculated in wounds with pieces of gall from the outer portions of galls taken from plants of the kinds mentioned.

In addition to these experiments, later and more extensive experiments with apple and pear seedlings carried on both in the field and the greenhouse with 15,000 carefully selected seedlings inoculated similarly with galls from the almond, apricot, blackberry, cherry, peach, plum, and rose gave results indicating that the soft galls occurring on the apple, pear, and rose are also forms of the same disease. Smith and Townsend[c] have shown that galls on peach trees can be produced by inoculations with pure cultures of *Bacterium tumefaciens* Sm. & Town., the cause of the formation of the galls on the Paris daisy. Coupling this fact with the results of the writer's experiments, it is possible that the soft galls of these plants with which he has experimented are caused either by the same organism or by closely related forms.

[a] The recent discovery of the bacterial nature of the crown-gall of peach trees and certain other plants clears up in a considerable measure the doubt regarding this important disease. The experiments here briefly described by Doctor Hedgcock were carried out before the cause of the disease was known, and are important in showing the extent to which cross-infection ordinarily takes place from one variety of plants to another. It is believed that the results are of sufficient practical as well as scientific importance to warrant their publication in this brief preliminary note.—B. T. Galloway, *Pathologist and Physiologist and Chief of Bureau.*

[b] Science, n. s., vol. 22, pp. 120, 121, July, 1905.

[c] Science, n. s., vol. 25, pp. 671–673, April, 1907.

EXPERIMENTS WITH CROWN-GALL.

Many of the writer's experiments with the soft form of crown-gall on apple and pear seedlings have given negative results. These experiments were usually small in extent. The results from three of the larger experiments are presented here.

In the most extensive experiments with the apple, healthy seedlings were carefully washed and divided into four lots of approximately the same number. The plants of one set were wounded by making a downward, slanting incision into the root, and then the wound was wrapped with thread in the same manner that grafts are wrapped, to be used as a control. A second control set was treated similarly, except that a chip or piece of clean, healthy apple root was inserted in the wound before wrapping. A third set was prepared like the first, except that a piece of soft apple gall was inserted in the wound. A fourth set was prepared similarly, except that a piece of hard apple gall was inserted. The seedlings in this and the following experiments were prepared, planted, and grown under the personal direction and observation of the writer. The trees were dug after growing one season, with the following results.

Of 977 trees grown in the first control, wounded only, 1.4 per cent were diseased with crown-gall, chiefly of the hard form; of 920 trees in the second control, with healthy chips in the wounds, 1.5 per cent were similarly diseased; of the set of 851 trees inoculated with soft gall, 10.9 per cent were diseased with galls of the soft form and 2 per cent with those of the hard form; of the set of 821 trees inoculated with galls of the hard form, 2.1 per cent were diseased with galls, principally of the hard form.

These results, in the writer's opinion, show quite conclusively that apple crown-gall in its soft form is contagious, but that in the hard form it is either slightly or not at all contagious. Should it be shown later that the two forms are results of infection by the same organism it will probably follow in the case of the hard form that the apple tree has been able to resist and largely overcome the effect of the parasite by healing processes which lower its vitality. That such may be the case is shown by the results from several large experiments with grafted apple trees where the percentage of galls on nursery trees decreased rapidly for three years.

Another experiment carried out similarly with healthy apple seedlings resulted as follows: Of the control set in which the trees were wounded only, 0.8 per cent of 657 trees were diseased with galls, chiefly of the hard form; of the control set of 672 trees with inserted healthy chips, 1.2 per cent were similarly diseased; of 627 trees inoculated with chips of dead peach gall, 3.1 per cent were diseased with galls, nearly all of the soft form; of 640 trees inoculated with

chips of dead raspberry gall, 3.3 per cent were similarly diseased; of 605 plants inoculated with chips of live rose gall, 3.5 per cent were diseased as before. Although the percentage of infection in this experiment is very low, the soft galls produced by the inoculations were so typical of those which occur on stone fruits and roses, even to the rotting away of numbers of them at the close of the growing season, that it is very evident that the disease is the same on the apple as on the stone fruits where the galls have the soft form.

In a third experiment 1,600 healthy pear seedlings were prepared, planted, and grown as in the former experiments, inoculations being made with chips of gall from the following plants: Almond, blackberry, cherry, peach, raspberry, and rose. Galls from a number of other plants were used with negative results, but those named gave positive results, as follows: Of the control in which the trees were wounded only, none was diseased with galls; of the control in which the trees were inoculated with healthy chips, 1 per cent was diseased with galls, about half being of the soft form; of the trees inoculated with almond gall, 4.2 per cent were diseased with soft galls. The other sets showed the percentages of plants diseased with soft galls to be as follows: Blackberry galls, 9.5 per cent; raspberry galls, 6.6 per cent; peach galls, 7.8 per cent; rose galls, 15.8 per cent. These positive results prove that the soft galls of the pear are identical with those of the stone fruits and the raspberry, the blackberry, and the rose.

SUMMARY.

From the results obtained by five years' experimentation in the greenhouse with seedlings grown under carefully regulated conditions, the following facts are noted:

The soft galls from the almond, apricot, blackberry, cherry, peach, plum, prune, and raspberry have been transferred easily to seedlings of the almond, apricot, peach, and raspberry; less readily to those of the blackberry, cherry, plum, prune, and pear; and with great difficulty to seedlings of the apple, chestnut, walnut, and rose.

The soft galls of the apple, chestnut, walnut, rose, and pear, as a rule, have not been transferred readily to any of the plants mentioned. Evidence has been obtained of a wide range of susceptibility in different varieties of the same plant. This has been noted in varieties of the apple, blackberry, cherry, chestnut, pear, and rose.

B. P. I.—376.

RECENT STUDIES OF THE OLIVE-TUBERCLE ORGANISM.

By Erwin F. Smith, *Pathologist in Charge of the Laboratory of Plant Pathology.*

INTRODUCTION.

In recent years the olive orchards of California have suffered considerably from swellings on the branches, known as olive tubercles and attributed to bacteria. This disease was first described in Italy, at least in modern times, albeit imperfectly as regards its cause. It has been known since Roman days.

DEPARTMENT EXPERIMENTS.

A desire to learn the natural methods of infection and the exact biology of the organism in the hope that this might bring to light some method of coping with the disease led the writer, in 1903, to begin a systematic study of the olive tubercle, which has continued to date, material being obtained from California and subsequently from Italy. Mr. James Birch Rorer was associated with the writer in the earlier work.

The right organism was plated out of the tumors without difficulty and determined to be a schizomycete. Numerous inoculations by needle puncture were made on sound olive trees in one of the hothouses of the Department of Agriculture with very satisfactory results. During this study it was learned that a yellow schizomycete, perhaps more than one, quite frequently accompanies or follows the parasite, and that occasionally nonpathogenic white bacteria also occur in the tumors. These yellow and white organisms were determined to be nonpathogenic by needle-puncture inoculations. All of the inoculations were made on young growing shoots of the olive. No fungi were found in the tubercles used for the poured-plate isolations, but subsequently fungi were found in some of the old tumors.

During this year (1903) tumors were produced on about 50 olive plants by pure-culture inoculations (on every one inoculated), and with pure cultures plated therefrom a second crop of knots was produced, thus complying with Koch's rules of proof. Many control

punctures on the same plants healed promptly. During the entire seven months only one accidental infection occurred, and this one could be accounted for satisfactorily, i. e., it appeared lower down on a branch already inoculated and forming a tumor. Such being the results, no reasonable doubt remained as to the possibility of producing the tumor with pure cultures of bacteria, nor from our studies was there any doubt as to the particular organism involved. Our experiments fully confirmed Savastano's statements respecting the bacterial origin of the tumor, but the parasite was white, not yellow as stated in literature. These facts were set forth in December, 1903, in an address before the Society for Plant Morphology and Physiology, illustrated by stereopticon and by inoculated plants, an abstract of the same being published in Science.

During the four years which have elapsed since this preliminary note, many additional successful inoculations have been made (the total number of inoculations now exceeding 500), and occasional accidental infections have also appeared on the experimental olives, all of the plants being in one place from the start. These latter, however, have been comparatively few and in no way confusing. About 150 olive plants of several varieties were used for these experiments. They were rooted cuttings from sound plants which had been grown in one of the hothouses of the Department of Agriculture for many years.

OTHER RESEARCHES.

About the same time as the writer, Ruggero Schiff, subsequently known as Schiff-Giorgini, began experimenting on the olive tubercle in Italy. His first paper was published in German in 1904. This was followed in 1905 by a second paper in German and by a longer paper in Italian, wherein he furnished additional evidence of the same character as that given in his first paper. Doctor Schiff claimed to have obtained successful infections with a schizomycete totally different from that isolated in our laboratory. He also stated that cultures of the *Bacillus oleae* are flocculated or agglutinated by juice from tubercles, but not by juice from sound parts of the plant. Fortunately, he described his organism so carefully that no doubt remains as to exactly what he meant by it.

In 1905 the writer called attention to the discrepancy between his own and Schiff's studies, stating some of the points of disagreement, and venturing the statement that no olive knots could be produced with pure cultures of Schiff's organism.

About this time Dr. Amedeo Berlese, an Italian, became interested in knots on olive trees; distinguished, incorrectly it would seem, two distinct forms of tubercle; and cultivated from the ordinary form a yellow organism, inclined to orange, supposed by him to be *Bacillus oleae*

(Arc.) Trevisan, and from the other form a white organism said by Petri to be Schiff's bacillus.

Moreover, in 1905, Peglion, in Italy, described a tubercle from the oleander, noted its anatomical resemblance to the olive tubercle, isolated a schizomycete therefrom, with characters like *Bacillus oleae* (Arc.), and made inoculations, but did not wait for results before publishing. This organism, isolated by Peglion, is unlike the olive-tubercle organism, and in Doctor Petri's experiments and our own, a culture of it having been given me by Doctor Petri, also proved non-pathogenic to the oleander.

In 1906 Clayton O. Smith, of California, also described the oleander tubercle, cultivated a schizomycete therefrom, secured inoculations on oleander and olive, and definitely identified the organism as *Bacillus oleae* (Arc.) Trevisan, the growth of this organism on potato being described as spreading, raised, and always straw colored. Peglion's work is not mentioned.

One of Doctor Schiff's colleagues, Dr. Lionelle Petri, assistant to Doctor Cuboni in Rome, took up the subject in 1905, by this time a rather confused one. After experimenting for a period of two years he published a paper in German in 1907, in which he states that both Schiff-Giorgini and Berlese are wrong, the only infectious organism of the three studied by him being that isolated and described by Smith in 1905. The *Bacillus oleae* (Arc.) Trevisan is a mixture. On agar both elements of this mixture may remain alive for some time, or one may destroy the other.

INOCULATIONS WITH SCHIFF'S BACILLUS.

My note of 1905 in the Centralblatt did not cover all my knowledge of the olive tubercle. I included in this note only enough to show that Schiff-Giorgini and myself were experimenting with entirely different organisms and that probably both of us could not be right. I had not then experimented with his organism, but I assumed that Schiff was wrong because we had produced fine examples of the olive tumor repeatedly (50 of them in 1903 and a great many since) with my organism, while he passed over the etiology of his organism with a few inconclusive remarks, to wit:

> It is unnecessary to dwell on the pathogenicity of *B. oleae;* it has already been demonstrated by others, as I said above in speaking of the work already extant on this subject. In addition I will say that I have repeatedly caused the tuberculosis in healthy olive plants, using pure cultures of *B. oleae* in glycerinated broth.

This is all Schiff has to say on inoculation experiments in his paper of 28 quarto pages. In the earlier German papers he barely mentions the subject. I did not consider Berlese's note of any importance, because he did not confirm his statements by successful inoculations.

At the time of my note to the Centralblatt in 1905, I had not seen Schiff-Giorgini's organism, but I obtained it toward the end of 1905 from Kràl, who had it from Kornauth, and made inoculations with it on olive shoots in 1905 and 1906.

All of these inoculations failed, although they were several times repeated, for the most part on young, actively growing shoots, using young cultures and inoculating very copiously with needle pricks on varieties of olives very sensitive to the knot. Altogether about 50 inoculations in three series (including 500 or more punctures) were made with this organism at considerable intervals during a period of about two years, using slant-agar for the first lot, potato cultures for the second, and slant-agar for the third. Not a single tumor developed. In one or two cases only there was a slight swelling in the pricked area such as check punctures sometimes give, but none of these developed into knots, and they were only slight cicatrization elevations. Bacteria were present at the end of a year in some of these punctures, as determined by a microscopic examination of sections. Possibly these slight wound reactions are what Schiff-Giorgini identified as tubercles, for he states that he obtained the disease with "pure cultures" of his organism repeatedly (ripetutamente); or it may be that his inoculation experiments were made with mixed cultures (they were fluid cultures at any rate); or, finally, it may be that they were made on limbs of olives already infected with the tubercle organism and ready to develop tumors. Tubercles on olive trees being more easily observable, if they had been present, than mixtures of bacteria in his fluid cultures, the second supposition is probably the correct one, since Schiff says that the olive trees used were sound ones and that the inoculations were from "glycerinated broth." My twelve olive plants were under examination for many months, and in some instances, especially in the final inoculations, a much greater amount of Schiff's organism was inserted than it has ever been my custom to use in the case of the true tumor-producing organism.

I can therefore confirm Doctor Petri's statement respecting this organism, my own inoculation experiments being perfectly in accord with his. The Schiff-Giorgini organism, which has various well-marked characteristics and is not likely to be mistaken for any other organism peculiar to the olive tree, is not the cause of the olive tubercle, and Schiff's conclusions, therefore, as to immunity, resistance, agglutination, etc., can not be accepted.

There can be no doubt, I think, that I had Schiff-Giorgini's organism, since, except in some slight details likely to vary from culture to culture and person to person, it corresponded perfectly with his own very full description, as I took care to find out before making many

inoculations. Kràl wrote to Schiff for it, who said he did not have it any longer, but perhaps Professor Kornauth would still have it, as proved to be the case.

AGGLUTINATION TEST.

The writer repeated the agglutination test described by Schiff, using young bouillon cultures of the right organism and the juice of a fresh large knot mixed with barely sufficient water to enable one to filter it satisfactorily through a Chamberland bougie. The peptone was thrown out of solution by this fluid, but the bacteria continued separate and motile; they were not in any way clumped by one or two hours exposure or even by exposure over night, nor when one part of the bacterial fluid was put into as much as ten parts of the juice and examined in a hanging drop. Moreover, even if Schiff had had the right organism, twenty to forty hours is altogether too long to wait for an agglutination.

SAPROPHYTIC BACTERIA IN TUBERCLES.

I find it difficult to believe that Schiff-Giorgini's organism occurs in all natural olive knots or that there is any symbiotic relationship. As already stated, saprophytic bacteria frequently occur in olive tubercles, and Doctor Petri touches on the possibility of symbiosis, without, however, committing himself to it. My original belief was that Schiff must have obtained his organism from the surface of an imperfectly sterilized potato culture or from the surface of the olive tubercle, but from Doctor Petri's observations we must now conclude that it occurs in the interior of some of the tubercles. The yellow organisms called *Ascobacterium luteum* by Doctor Petri may occur in all old knots, since we may assume them to be common on the surface of olive trees, just as certain nonpathogenic forms are common on the skin of animals, but they are not by any means always in young knots. In certain poured plates where I found yellow bacteria in conjunction with the right organism I had good reason to think the surface of the tubercle had been insufficiently sterilized (thirty seconds). Neither Schiff's organism nor the yellow form isolated by Berlese is necessary for the production of the tubercle, as Doctor Petri has also shown. In Petri-dish poured plates made from olive tubercles collected in autumn and winter, or in early spring before new growth has commenced, probably also in late summer, one might expect to find various intruding bacteria, also fungi. I have found the bacteria very frequently, especially the yellow ones. Schiff's organism I have not, so far, found in the tubercles. In two instances I have obtained only the nonpathogenic yellow organisms from olive tubercles, but these were at least 6 or 8 months old, and perhaps older—too old

anyway. One lot came from Naples and the other from Tunis. Schiff's mistake arose from the belief that anything found in the tubercle must necessarily be the cause of it. That he did not discover and correct his mistake later on is due to the fact that his inoculations were not properly controlled.

NOMENCLATURE OF THE OLIVE-TUBERCLE ORGANISM.

The nomenclatorial vicissitudes in connection with the olive-tubercle organism may be stated as follows:

1886. *Bacterium oleae* Arcangeli: Bacteria seen in cavities in the tubercles and name given without measurements or any description, except the statement that they resembled *Bact. termo.* The cavities also contained mycelium and spores. No bacteriological studies were made. Statement hazarded that the bacteria had nothing to do with the production of the tubercles which arise in wounds. The tubercles were described quite carefully and attributed to physiological disturbances favored by special predisposition.

1889. *Bacillus oleae tuberculosis* Savastano: Studies begun in 1886; tubercles produced in 1887 and again in 1889 with cultures of bacteria obtained from the knots. Organism described as a motile short rod, which is whitish or yellow on culture media and sometimes liquefies gelatin, while at other times it does not.

1889. *Bacillus Prillieuxianus* Trevisan: A name based on Prillieux's account of the disease and given without study or proper description.

1889. *Bacillus oleae* (Arc.) Trevisan: A simple transfer to another genus. The description is borrowed (curtailed) from Savastano. *B. Prillieuxianus* is placed under it as a synonym; also *B. oleae tuberculosis.*

1904–1905. *Bacillus oleae,* the cause of olive tubercle, stated by Schiff-Giorgini to be a white to dirty yellow, polymorphic, peritrichiate bacillus, producing spores very readily, forming long chains and tangled threads suggestive of the anthrax organism, producing a prompt pellicle on bouillon, liquefying gelatin, coagulating milk, growing readily at 37° C., withstanding a temperature of 102° C., etc.

1905. The olive-tubercle organism stated by Erwin F. Smith to be a white, nonsporiferous, nonliquefying organism, consisting of short rods, motile by means of polar flagella, unable to grow at 37° C., killed by a temperature of 50° C., incapable of coagulating milk, etc. Yellow and white nonpathogenic bacteria stated to occur in the tubercles.

1907. *Bacillus oleae* (Arc.) Trevisan, stated by Petri to be a "Sammelname," which splits up on study into *Bacillus oleae* α (Smith), the

true parasite; *Bacillus oleae β* (Schiff-Giorgini), a nonpathogenic organism; and *Bacillus oleae γ*, which in Berlese's cultures is *Ascobacterium luteum*, a nonpathogenic, liquefying peritrichiate form, and in Savastano's cultures is *A. luteum*, mixed with Smith's organism, an assumption believed to be required by the fact that Savastano describes his organism as sometimes liquefying gelatin and as yellow on some media and yet obtained tubercles on making inoculations.

Such being the situation, by what name shall the olive-tubercle organism be known?

The earliest name, Arcangeli's, is practically a nomen nudum, since the description accompanying it does not presuppose pathogenicity nor enable anyone to determine what organism was intended. Arcangeli's entire description is as follows:

> But I constantly found between the irregular cavities placed more or less deeply (whose walls were oftentimes more or less chestnut colored and changed) colonies of a bacterial form like *Bacterium termo*, which I shall call *Bacterium oleae*, together with mycelial filaments, possibly of a Cladosporium, and spores of fungi.

Savastano was the first man to isolate bacteria from the olive tubercle and to secure infections. His name is the next earliest, but it is a trinomial, and a part of his description is drawn from mixed cultures. The organism does not liquefy gelatin and is not yellow.

Trevisan's names are inadmissible because he merely copied earlier vague statements and no one can tell from his descriptions what organism was intended. This is shown admirably by the very diverse interpretations which have followed, e. g., Berlese's and Schiff's. Indeed, the subject is in such confusion that in recent years no less than four distinct organisms have been considered to be *Bacillus oleae* by different writers.

After careful consideration, to avoid further confusion, the writer has decided to give an entirely new name to the organism isolated by himself, and, in order that Savastano may not fail of due honor, he has decided upon the name *Bacterium Savastanoi*, with the following characterization:

DESCRIPTION OF THE OLIVE-TUBERCLE ORGANISM.

Bacterium Savastanoi (nov. nom., nov. descript.)

Synonym (pro parte): *Bacillus oleae tuberculosis* Savastano.

Names of doubtful import, to be rejected: *Bacterium oleae* Arc.; *Bacillus Prillieuxïanus* Trev.; *Bacillus oleae* (Arc.) Trev.

Latin diagnosis.—Baculis cylindricis apicibus rotundatis, longitudine variantibus, solitariis vel in filamentis brevibus dispositis; baculis unis saepe 1.2–3 × 0.4–0.8 μ; se moventibus, aerobiis, asporis.

Hab.: In tumoribus Oleae europeae. Coloniae in gelatina tenues, albae, marginibus inaequales, nonliquefacientes. Coloniae in agar-agar albae, rotundae, nitentes, evolventes lente (in extremo die septimo 2–5 mm. latae). Culturae in tuberibus Solani primo albae, dein pallidae fulvae-albae sunt. Lac sterile alcalinum fit et casein non-segregatur. Baculi methodo Gram noncolorantur. Nitrum non-redigitur. Acidum in mediis cum saccharo uvae celeriter fit. Si culturae novae in infusione carnis ¼ horam in temperatura 50° C. tenentur, moriuntur. Inter temperaturam 35° C. et temperaturam 1° C. crescit. Inoculatum in Oleas sanas, tumores proprios producit.

A white, nonliquefying schizomycete, causing olive tubercle. This organism is found in the olive tubercle and in many culture media as a short rod with rounded ends, either single or in pairs, growing end to end, or in small clumps, more rarely in short chains; the rods taken from the interior of an unruptured tubercle measured 1.5 to 3 × 0.6 to 0.8 μ when stained by carbol-fuchsin and washed in water; the rods from young agar cultures stained with carbol-fuchsin usually measure about 1.2 to 1.5 × 0.5 μ; rods from 3 days' old colonies on agar measured 1.2 to 2 × 0.4 μ when stained by a modified Gram, i. e., washed in amyl alcohol, and cleared in xylol; more rarely they are 10 μ or more in length; in bouillon kept for three days at 30° C. the thinly clouded fluid examined in hanging drops contained numerous actively motile rods five to twenty-five times as long as broad, some of the long rods plainly constricted in the middle, others not, the long ones flexuous;[a] the organism is motile by means of one to several polar flagella, often 2 to 4 (Pitfield's flagella stain), the rods so stained being 2 to 5 × 0.6 to 0.8 μ.

Young motile agar cultures stain readily with carbol-fuchsin, but not by Gram; the organism is aërobic and very sensitive to heat; the growth is white in various culture media (bouillon, peptone water, milk, standard agar, sugar agars, gelatin (especially at bottom of slant), silicate jelly, starch jelly, Cohn's solution, Fermi's solution, Uschinsky's solution); on +15 nutrient agar in poured plates made from bouillon and incubated at 20° C. or 25° C., the surface colonies are small, circular, smooth, glistening (internal structure reticular), rather slow growing, appearing at the end of the second and third days and best observed after three to four days, becoming denser and whiter with age;[b] the intruders usually come up first in plates made

[a] In a repetition made in 1908 the same result was obtained: The longest single rods were 3 μ; the chains varied from 6 to 40 μ; some of the chains were actively motile.

[b] In +15 standard nutrient agar in Petri-dish poured plates made recently and kept at 22° to 23° C. the surface colonies in thin-sown plates were pure white, rather slow growing (1.5 to 3 mm. at the end of the third day), round, flat, surface smooth, glistening, edge entire or nearly so, internal structure under the compound microscope amorphous to finely granular; buried colonies quite small. At the end of seven days

from the tubercles, and often the right colonies are then best observed after four to six days; bouillon is thinly clouded, and there is finally a small amount of white precipitate—in four days at 20° C., no rim, pellicle, or flocculence; on peptone water a white pellicle after some

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the surface colonies were 2 to 5 mm. in diameter and more or less viscid, the slime sometimes stringing up 1 cm., the margin was undulate and there was often a ring. In another set of agar plates made some days later and studied with equal care, the surface colonies were 0.7 to 1.3 mm. in diameter after forty-eight hours at 23° C. The margin was entire. The surface was wet-shining and smooth. The internal structure under the hand lens was reticular. Under the compound microscope it was amorphous to finely granular. The buried colonies were small biconvex. At the end of seven days the surface colonies were white, circular, ringed or not. The surface was smooth and wet; the internal reticulations were still visible under the hand lens. Under the 16 mm. and 12 ocular the colonies were finely granular.

In +10 gelatin poured plates made at the same time, the surface colonies were 1.5 to 2.5 mm. in diameter at the end of four days at 21° C. They were white, slow-growing, round, flat, with undulate, erose, paler white margins, and fine internal striæ. There was no liquefaction. After some weeks the margins were decidedly lobed.

On gelatin the marginal growth is quite characteristic and distinct from the body of the growth, both in colonies and in streaks. The edges of the streaks and colonies are often more or less lobate or incised. Savastano observed this and likened the appearance to that of a leaf. Whenever the slime runs down from the streak it is seen to be white, but often the growth on gelatin is so thin that the yellow color of the gelatin shows through and might thus lead to confusion.

Often after some days a brownish stain is produced on potato and in the fluid and this modifies the color of the bacterial growth, but it can scarcely be called yellow; perhaps tawny or tawny-white comes nearest to describing it. A similar color occurred in the older zoogloeæ forming the rim of two flask cultures containing river water, calcium carbonate, Witte's peptone, and grape sugar.

In undisturbed test-tube cultures in water containing 2 per cent Witte's peptone, a thin white surface membrane forms after some days (five or six) and falls readily as a unit, being broken up only by rather vigorous shaking.

Two water solutions of copper sulphate were prepared, i. e., 1:100,000 and 1:500,000. One-half cubic centimeter of a young, thinly clouded bouillon culture was pipetted into 10 c. c. of each one of these two coppered waters. Checks were held by pipetting one-half cubic centimeter of the same bouillon culture into each of two tubes containing 10 c. c. of pure water. Petri-dish poured plates were made with carefully measured quantities of the fluid at the end of one-half hour, one hour, two hours, and twenty-four hours. Check plates from the pure water dilutions were also made at the end of two hours and twenty-four hours. In all 36 plates were poured (three of each coppered water at each date and 12 check plates). Result: No distinct reduction in colonies by one-half hour, one hour, or two hours exposure; marked reduction after exposure for twenty-four hours. In the 1:100,000 solution *four-fifths* of the bacteria were destroyed. There was also a similar marked reduction in the weaker solution of 1:500,000. The colonies on the plates made from the coppered waters came up a day sooner than those on the check plates, the growth of those bacteria that survived being stimulated. By using a young bouillon culture rather than washings from an agar streak it was believed that the advantage would be in favor of the bacteria, since we may suppose some part of the copper would be rendered inert by the organic matter of the bouillon.

days; it blues litmus milk, the fluid, which is lavender or lilac on the start, becoming gradually a deep blue; it does not form acids in milk and does not coagulate milk by a lab ferment; it grows readily in Cohn's solution and for a long time, producing an abundance of crystals of ammonium magnesium phosphate, no difficulty being experienced in obtaining enough for a chemical analysis from small flask cultures; in old gelatin streaks and in old gelatin stab cultures there was a thin white surface layer, but no trace of liquefaction, growth along the line of the stabs was not well developed; in gelatin streaks and gelatin colonies there is an irregular undulatory lobed or incised margin; organism nonsporiferous, nonliquefying, nongas forming; growth on cooked potato at the end of two days was smooth, white, wet-shining, distinct, but not very copious, cylinder slightly grayed and fluid at the bottom moderately cloudy, the growth at first on potato being not unlike the pure white growth of *Bacillus trachei-philus*, even in old cultures the growth is never a decided yellow (see footnote); potato cultures eighteen days old gave a deep purplish blue reaction when mashed in iodin water, the checks giving a bright blue color, i. e., the organism acts but slightly on potato starch; action on olive starch unknown; it does not reduce nitrates in peptonized beef bouillon; it will not grow in beef bouillon at 38.5° C., and is killed in +15 standard beef bouillon by exposure in the water bath, in test tubes, for ten minutes at 50° C.; streak cultures on litmus agars containing filtered river water and Witte's peptone, but free from beef juice, behave as follows:

Plain litmus agar.—This becomes blue and remains so (forty days), growth moderate.

Litmus dextrose agar.—This reddens promptly (twenty-four hours, at 27° C.) and decidedly, and remains acid indefinitely (color bright red—not purple), growth slight.

Litmus galactose agar.—This reddens promptly and decidedly and remains acid (forty days); same reaction as with litmus dextrose agar, growth moderate.

Litmus saccharose agar.—This remains neutral or nearly so for some days, finally, however, becoming purplish and then purple-red; growth stimulated, i. e., a much greater volume of bacterial slime than on the other agars and the litmus reduced in the bottom of the tube after some days.

Litmus lactose agar.—This blues; growth not more than on the plain litmus agar; no acid was formed (thirty days).

Litmus maltose agar.—This blues, growth moderate; no acid was formed (thirty days), and there was no reduction.

Litmus mannit agar.—This blues, growth moderate, after ten days litmus purplish, never red.

Litmus glycerin agar.—This remains neutral or nearly so, i. e., in nine days only a trace of purpling and no marked increase of red in next twenty days, good growth.

The most striking reaction is the prompt complete reddening of the litmus in the presence of dextrose or galactose and its persistency.

A slight indol reaction (pink color) was obtained with sodium nitrite and sulphuric acid both in peptone water and in Uschinsky's solution with peptone, but it was less than half as deep as that obtained with *Bacillus coli* and it did not form as promptly;[a] the organism has lived in agar in the ice box upward of four months; it grows in +15 bouillon at 1° C. and would probably cloud the fluid at 0° C.; 60 to 90 per cent of the rods were killed by freezing (liquid air); it clouds bouillon over chloroform.

In flask cultures in river water containing 2 per cent Witte's peptone and 2 per cent dextrose, there was very copious growth, but most of the bacteria were dead at the end of six weeks, probably because there was a decided acid reaction, in spite of the presence of a small amount of calcium carbonate. The fluid bore floating islands, but no continuous pellicle. Free oxygen is necessary for the production of this acid, i. e., in fermentation tubes containing filtered river water, Witte's peptone, and dextrose or galactose, the clouding, which was prompt and copious, was confined to the bulb and the outer three-fourths of the U, with a sharp line of demarcation where the bacterial growth ceased. Six tubes were inoculated, three of each sugar, and all behaved alike. There was not a trace of clouding in the closed end up to the end of the sixth day, when the experiment was broken off. The organisms from California and Italy behaved alike. The mixed fluid from the open end of the three bulbs containing grape sugar was acid to litmus paper and titrated +41 on Fuller's scale, using phenolphthalein and sodium hydrate; that from the closed end was neutral to litmus and titrated +20 with phenolphthalein and sodium hydrate. The mixed fluid from the three bulbs containing galactose titrated +30; that from the closed end +20. There was no loss of acidity on boiling thirty minutes.

The organism is sensitive to sunlight. In thin sowings in six Petri-dish poured plates in +15 standard agar, exposed on ice, bottom up, to bright sunlight for thirty minutes in April, the covered one-half of each plate promptly developed from 100 to 150 colonies; the exposed one-half of each plate, on the contrary, remained entirely free from colonies (eight days). The temperature did not exceed 18° C.

It appears to be sensitive to acids. The organism is sensitive to copper sulphate (see footnote).

[a] This was repeated in 1908 in peptone water with what appeared to be a negative result, but on standing some days the fluid in the culture tubes became pink, while that in the check tubes did not. These cultures were ten days old.

When inserted by needle punctures into young growing leaves or shoots of the olive, it causes the characteristic galls known in Italy as *rogna* or *tuberculosis* of the olive, and in California as *olive-knot, tumor,* or *tubercle.* In my inoculation experiments it has required three to four months for the tubercle to become full grown, and nine to fifteen days for the appearance of elevations on the stem of unmistakable tuberculous character. Earlier than this it has not been possible macroscopically to detect the incipient tubercles with any certainty. Inoculations are most successful when made on the tips of undeveloped shoots in active growth. It is impossible or difficult to induce the formation of tumors on slow-growing or dormant tissues. The organism is most easily recovered in pure culture by making poured plates from the interior of young knots which have not developed fissures, the surface being first sterilized for five minutes in 1:1,000 mercuric chlorid water. The organism does not lose its virulence readily by continued culture in the laboratory, but I have seen some indications of such loss, i. e., slow development of tumors and a larger proportion of failures.

The disease occurs in Italy, France, Spain, Algeria, Tunis, California, etc., injuring the olive and sometimes destroying it. The organism enters the plant, so far as yet known, exclusively through wounds, and sets up an extensive hyperplasia involving various tissues. I failed to obtain the disease by spraying a water suspension of a young virulent culture upon an actively growing olive shoot, kept in moist air under a bell jar. Moisture in tiny drops persisted on the leaves and stem for a good many hours, but no tubercles resulted (only one experiment, however). The bacteria occur at first between the cells and in small irregular closed pockets, but as the tubercle grows it splits open, foreign organisms appear, and decay sets in. Metastasis occurs, i. e., there are two distinct types of tubercles, primary and secondary, the former due to external infection and beginning in the cortex, the latter due to internal infection and beginning deep in the tissues at the junction of wood and pith.

METASTATIC TUBERCLES.

Metastasis was discovered by Schiff-Giorgini. This was observed and studied by him on natural infections. Recently the writer has also observed it in 10 secondary tumors on shoots and leaves of the 16 inoculated plants referred to below as checks on the oleander inoculations. On one of the leaves the outbreak of the metastatic tubercle, which was watched from its incipiency and before it ruptured the epidermis, appeared on the midrib 4 cm. above the point of inoculation, which was on the stem. On one of the shoots it appeared at a distance of 7 cm. above the primary tubercle. These

secondary tumors are not due to the migration of host cells, but are the result of migrations of the bacteria, which set up local irritations where the secondary tumor arises. The bacteria make their way from the point of inoculation by way of the vascular system. They are easily observed in some portion of the vascular system, usually a very small portion of it, at points anywhere between the primary and the secondary tubercle. In the cases I have studied they were confined to small canals in the inner wood next the pith, these canals being due to the disorganization of a group of vessels. The bacteria were abundant and the walls of the canal were stained yellow and brown. The giving way of the woody structure and the flooding out of the bacteria into softer tissues is apparently what determines the appearance of a secondary tubercle at any particular spot. By splitting the stem lengthwise in the proper place one can trace the canal of infection leading from the primary tumor to the secondary one as a small stained line at the inner border of the wood, easily visible to the naked eye. Sometimes the bacteria are numerous enough in the canal to form a slight ooze on cross section.

THE INOCULATION OF OTHER PLANTS.

This organism apparently is not infectious to *Nerium oleander*. Only six oleander plants were tried, but these very thoroughly, i. e., 18 sets of punctures on as many young actively growing shoots, using agar streaks forty-eight hours old and inoculating very thoroughly, a total of about 150 needle punctures being made. These plants were under observation for five months. No tumors developed. Sixteen olive shoots were held as checks on these oleanders and developed 16 groups of tubercles corresponding to the points of inoculation, and also subsequently metastatic tubercles, as above mentioned. At present, therefore, I am unable to explain the counterstatements of Clayton O. Smith. The oleander tubercle seems to me to be due to *Bacterium tumefaciens* Smith and Townsend.

Apparently the organism is not infectious to *Chrysanthemum frutescens*, i. e., at the same time that the oleanders and olives above referred to were inoculated, actively growing shoots of 12 white daisy plants were inoculated by needle puncture from the same set of cultures. About 120 needle pricks were made and the inoculation was done with great thoroughness, but no tumors developed (five months). *Bacterium tumefaciens* would have produced visible results on the same plants in five to seven days and large tumors in two months.

The above-mentioned sets of inoculations were made in 1907. Earlier in the course of experimentation numerous attempts were made to inoculate the olive disease into ash trees of several species,

privet, and other plants more or less closely related to the olive, but none of the experiments were successful. I still believe it might perhaps be inoculated into *Fraxinus ornus*, my experiments with this species being limited in number and cut short by an accident. Certain slight swellings were visible at the time the plants were destroyed, but the results were not assured. Schiff-Giorgini states that the disease does not occur on the wild olive.

SCHIFF'S ORGANISM A POTATO BACILLUS.

Schiff's organism is *Bacillus vulgatus* (Flügge) Migula or some closely related form, possibly a form near *Bacillus pseudanthracis* Kruse. This will become evident from the following considerations.

SCHIFF'S OWN STATEMENTS.

The principal statements of Schiff respecting the morphology and cultural characters of his organism are condensed as follows from his Italian paper, the starred sentences being observations which the writer has confirmed, using the cultures received from Kornauth:

The organism occurs in the form of long chains or tangled filaments which are usually nonsporiferous, nonmotile, and on staining are seen to be composed of short rods with square ends.* There are also numerous short motile rods with rounded ends, and these in great numbers change quickly into endospore-bearing bodies when grown in culture media.* Transitions occur, the chains becoming shorter and disappearing in old cultures.* Short rods sometimes contain minute irregular granules.* These rods are greenish transparent.* In young cultures on agar, forms occur with and without polar staining. The motile short rods with rounded ends when taken from agar measure 1.6 to 2.2 $\times$ 0.6 to 0.8 μ, or from young cultures 2.5 $\times$ 0.9 μ. On sugar agar they measure 2 to 3 $\times$ 0.8 μ. In broth they are 2 to 3 $\times$ 0.8 μ, or when in chains the segments are 1.8 to 2 $\times$ 0.7 μ. The organism stains by Gram.* We have, therefore, short rods, short chains, long chains, and pseudo filaments, the ends rounded or truncate, and the elements motile or nonmotile depending apparently on whether they are separate or fused into the filaments.*

In suitable media the endospores begin to form the first or second day and finally become more abundant than the nonsporiferous rods.* The sporangia are short elliptical rods in which the endospore is borne centrally and fills nearly the whole body of the sporangium, the latter being swollen slightly around the spore.* Rarely the spore is borne at one end in a swollen portion. The sporangia measure 3 $\times$ 1.2 μ; the endospores measure 1.6 $\times$ 1 μ. The sporangia disappear by solution. The germination of the endospore is central, rarely polar. The flagella are three to four times as long as the rods; they are peritrichiate and eight to ten in number.* They were stained by Gaurnier's method. There is a thin capsule.

On agar the growth is abundant, spreading, lobed, flat.* It is glistening, smooth, becoming rugose, translucent, white to dirty yellow.

On glycerinated potato, growth is abundant, persistent, raised, transparent, white to dirty yellow,* gelatinous.

On glycerin agar, a dry pulverulent surface.

On sugar agar a very rapid spreading growth visible in four to eight hours, slime tenacious. Organism not much inclined to form acids.*

In agar stabs growth best at the top.* Surface growth restricted, lobed; no line of puncture.

Gelatin stab: Liquefaction funnel shaped, abundant at 20° C.*

Nutrient broth: Growth rapid, rim and pellicle present, the latter wrinkled, clouding moderate, fluid turbid, browned, sediment granular pulverulent.* Broth cultures often contain long, tangled chains recalling *Aplanobacter anthracis.**

Milk is coagulated by a lab ferment and the extrusion of whey begins in two days.* Curd is peptonized in four or five days.

Agar colonies: Growth rapid, surface colonies round to lobed.*

The organism has lived nine months on culture media.* It is a strict aërobe.*

The optimum temperature for growth is 34° to 35° C.* Slow growth at 15° C. Grows well at 37° C.* Maximum temperature for growth 41° C. The spores are not killed by fifteen minutes at 102° C.

There is a slight production of acid on starchy media. Potato starch is destroyed.*

From the results obtained by Schiff we may assume the existence of at least three enzymes: Lab, trypsin, diastase.*

ADDITIONAL OBSERVATIONS BY THE WRITER.

To the foregoing I can add the following from my own studies:

The granules in the short rods stain deeply with carbol-fuchsin, becoming very pronounced. They are one to four or more in number. The length of the filaments from peptonized beef bouillon may be several hundred times their diameter and these long forms are not motile. They stain uniformly and deeply with carbol-fuchsin. Shorter filaments, however, were observed to be motile. The short rods taken from potato cultures were actively motile. I stained the flagella by Pitfield's method. They closely resemble the flagella of *Bacillus vulgatus.*

Intricate criss-cross marks are sometimes present in surface growths on agar. At other times the surface is smooth or finely granular under the lens. Copious wrinkling was readily obtained by adding cane sugar to the agar.

On glycerin agar a dry, white, rough, scaly growth was obtained. Growth on this medium was very abundant in the thermostat at 31° C. (50 times as much as at 20° C.)

In agar stabs the surface growth was thin, white, finely granular under the lens, finally spreading. A distinct stab growth appeared and this was best at the top.

The surface colonies on gelatin develop rapidly and are circular. The margin is fimbriate, as in the case of *Bacillus subtilis*, i. e., fringed with many parallel filaments. Next to this fringed portion in colonies two days old is a finely granular portion consisting of actively motile short rods. The center of the colony contains also tangled chains. These colonies measured 5 to 10 mm. in diameter and the gelatin was fluid except at the margin of the colony.

Gelatin stab: Growth gray white, best at the top; liquefaction rather rapid. It begins in about twenty-four hours at 24° C. and usually ends in five or six days. The tube of liquefaction is at first crateriform, becoming saccate.

A pellicle forms on the surface of milk. In litmus milk there was some formation of alkali but no distinct development of acid. The milk must therefore be coagulated by a lab ferment. In my hands the solution of the precipitated curd was not as rapid as described by Schiff.

In Petri-dish poured plates at 25° and 30° C. the growth of the surface colonies on +15 agar is rapid. They are round, soon becoming irregular, rhizoid; the lobes are often branched repeatedly, as in the case of *Bacillus aroideae*, if the agar is not too dry. The surface is smooth or slightly roughened, gray white, edges entire, becoming variously lobate. Long, narrow crystals are sometimes found in agar cultures.

On potato with 5 per cent glycerin added, growth at first was white or gray white, becoming isabella colored, growth abundant, spreading, rhizoid, dull (shining under hand lens) rugose with dense angleworm-like folds.

Growth on common potato is similar, that is, a much wrinkled, rather dry looking, spreading surface layer develops quickly. This soon thickens and the numerous worm-like folds disappear, so that at the end of six or seven days the surface presents a smooth, thick, shining layer. The substratum meanwhile acquires a slight pinkish tinge or red specks appear here and there. The starch in the potato is destroyed and growth continues for some weeks. The medium remains neutral or with slight variations to either side of the litmus neutral point. The potato cylinders are softened; after six weeks only traces of starch remain.

In Uschinsky's solution the growth was copious but the rim was scanty. No growth was obtained in peptone water with 0.2 per cent

malic acid. No growth was obtained in oxalic acid agar stab cultures. No growth occurs in Cohn's solution.

No gas formation was observed; organism not tested in fermentation tubes.

Peptone water with dextrose becomes dark brown. A nutrient mineral solution (nitrogen-free media) with the addition of sodium asparaginate and cane sugar became dark brown; organism also able to take nitrogen from ammonium lactate, ammonium tartrate, ammonium citrate, and ammonium phosphate. Organism does not grow readily or copiously in distilled water containing only asparagin or in Cohn's solution with asparagin substituted for ammonium tartrate.

Nutrient agar with addition of cane sugar acquires a reddish brown stain; so does also Hunger's sugar agar using either monopotassium phosphate or dipotassium phosphate. Plain agar did not stain.

Boiled white of egg appears to be acted upon slightly.

Growth in nutrient broth, glycerinated peptone water, Uschinsky's solution, Fermi's solution, etc., is best at the top.

Nitrates are reduced. No indol in old peptone water cultures could be detected with sodium nitrite and sulphuric acid.

The organism lives a long time on culture media. So far as I have observed it is a strict aërobe: It grows feebly in bouillon under olive oil (six days), and in shake-agar cultures buried as soon as solid under another 10 c. c. of agar with olive oil on top, visible growth occurred only in the upper 10 c. c. of agar, and the colonies were largest in the upper strata of this agar (four to nine days).

In streak cultures on litmus agars the organism behaved as follows:

In each of 16 streak cultures on litmus agar there was a copious growth in twenty-four hours, but in forty-eight hours no reddening with plain agar, or the same with addition of lactose, galactose, maltose, mannit, or glycerin. With dextrose and saccharose, however, the litmus was feebly purpled, and this change was visible in twenty-four hours. At the end of seven days the plain litmus agar and that containing lactose and galactose were either slightly bluer or not different from the check tubes. The others were purplish. These litmus agars contained, respectively, dextrose, saccharose, maltose, mannit, and glycerin. None were bright red, only purplish red, and that not very pronounced, although plainly different from the check tubes. The litmus glycerin agar was reddened least, and this change was not visible until after the fourth day. There was no reduction of the litmus in any of the tubes (ten days). After seventeen and thirty days the litmus was reduced in tubes with glycerin. In addition to the carbon compounds to be tested this agar contained only filtered river water and Witte's peptone. We may therefore conclude that the organism is only a slight producer of acids.

When taken from very young bouillon cultures made from similar cultures, i. e., in such a way as to obtain spore-free material, the organism is readily killed by drying. Cloudy bouillon from such tubes when spread on glass cover slips and preserved in ordinary covered Petri dishes for from five to nine days in a closet at room temperatures failed to cloud tubes of bouillon when thrown into them.

That part of Schiff-Giorgini's paper distinguishing two distinct forms of olive tubercle—the primary, due to external infection, and the metastatic or secondary, developing from within—is well worked out and marks a distinct advance in plant pathology.

THE DISEASE IN THE FIELD.

It has been observed over and over again in Italy and elsewhere that rich soil, heavy manuring, and excessive use of water favor the spread of this organism, by producing a great quantity of juicy tissues suitable for infection. This is also true of pear blight. Some varieties of olives seem to be more subject than others. Very sensitive ones should be discarded.

Old tubercles are often eaten by various insects, and it is possible that some insect carrier plays a part in the distribution of this disease. This can be determined only by a prolonged investigation of field conditions supplemented by laboratory studies.

The skillful use of the pruning knife offers some hope. Special knives should be provided for the pruning of diseased trees, or else all the knives should be disinfected after each tree is gone over. In pruning it should be remembered that in some instances the organism may occur in the interior of the stem, some distance below the tubercle. It is wise, therefore, to cut several inches below visible signs. A dab of disinfectant on the cut surfaces, if they are not too numerous, is also to be recommended.

Of germicidal sprays, two may be recommended for trial on a small scale at first, i. e., until it is known definitely whether or not the foliage of the olive will be injured by them. These substances are Bordeaux mixture and the self-boiled lime-sulphur mixture recently devised by Scott for the treatment of peach diseases.[a] If the olive tree will bear either of these germicides, then thorough tests for the control of the disease should be made by giving a half dozen sprayings in the actively growing part of the season.

[a] See Circular No. 1, Bureau of Plant Industry, 1908.

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B. P. I.—377

THE NECTARIES OF COTTON.[a]

By Frederick J. Tyler, *Scientific Assistant, Fiber Plant Investigations.*

INTRODUCTION.

Some natural method of grouping the species of cotton is greatly needed. The cultivated species especially have been confused since the time of Linnæus, and the genus is generally considered very difficult.

It is believed that the interesting diversity which has been noticed between the nectaries of different cottons will form diagnostic characters of considerable value. The nectaries do not change materially through years and even centuries of cultivation, and are not affected by the economic evolution of the plant.

Whatever their origin, they now act as lures for friendly insects and are unusually well developed in most of the species of cotton. Two distinct sets are present in the genus—the floral nectary, which

[a] With the increasing interest in the development of improved varieties of plants by breeding along definite lines there is a growing demand by economic workers for accurate knowledge regarding distinct species or botanical relationships. For plants that have been long cultivated it is of the utmost importance to find diagnostic characters not subject to variation or affected by cultivation or selection.

In the study of cottons with a view to the description and classification of the cultivated varieties of American Upland cotton a careful study of the species and varieties has been made from growing plants so far as possible. It has been found that the glands, organs of prime importance to the plant itself but of no recognized economic value, and therefore not subject to variation by selection, afford exceptionally good and well-defined characters for identification of groups of species. While some of these nectar-secreting glands have often been referred to heretofore, there has never before been an opportunity for a study of such a wide series, and the rather desultory observations have often been misleading. The results of careful observations made by Mr. Tyler on many hundreds of plants, representing many varieties and species, are here presented with a view to aiding in the determination and classification of the species of Gossypium. The nectary alone, or indeed any one character, is insufficient for classification, but this in connection with others will aid in the identification of species.—B. T. Galloway, *Physiologist and Pathologist, and Chief of Bureau.*

attracts insects useful in effecting cross-pollination, and the extrafloral nectaries, which are feeding places for insects useful to the plant in other ways.[a]

THE FLORAL NECTARY.

The floral nectary consists of a ring of papilliform cells at the base of the inner side of the calyx (see Pl. I, figs. 1 and 2). It is reached from within the corolla by long-tongued bees and butterflies, but is inaccessible to smaller insects, except those so small that they can crawl between the closely fitting calyx and corolla. The five petals overlap, except at their base, where there are five small openings leading down to the nectar. In many species of cotton these gaps are guarded by long, interlacing hairs, which offer no difficulties to the slender tongues of bees and butterflies, but effectually exclude insects too small to be of service as pollinators. The nectary is further protected in some species by a chevaux de frise of straight, stiff hairs, pointing upward toward the mouth of the calyx. These hairs are arranged in the form of a ring, often as broad as the gland itself and located just above it. (See Pl. I, fig. 1.)

The floral nectary has not been described, apparently, by those who have studied the glands of cotton. Trelease,[b] who examined our common cotton (*Gossypium hirsutum* L.), noticed insects putting their tongues through the gaps between the claws of the petals and supposed that the interlacing hairs previously mentioned as closing the gaps in some species were the nectar-secreting organs. Watt sometimes refers to the involucral glands as "floral glands," but overlooks the true floral nectary, although in one instance he figures the ring of hairs above the papilliform zone of the nectary of an African species.[c]

THE EXTRAFLORAL NECTARIES.

The three sets of extrafloral nectaries—the leaf, the outer involucral, and the inner involucral—have often been noticed by botanists and have been employed by them in describing species of cotton, but unfortunately those characteristics have been used which are most variable and of least specific value.

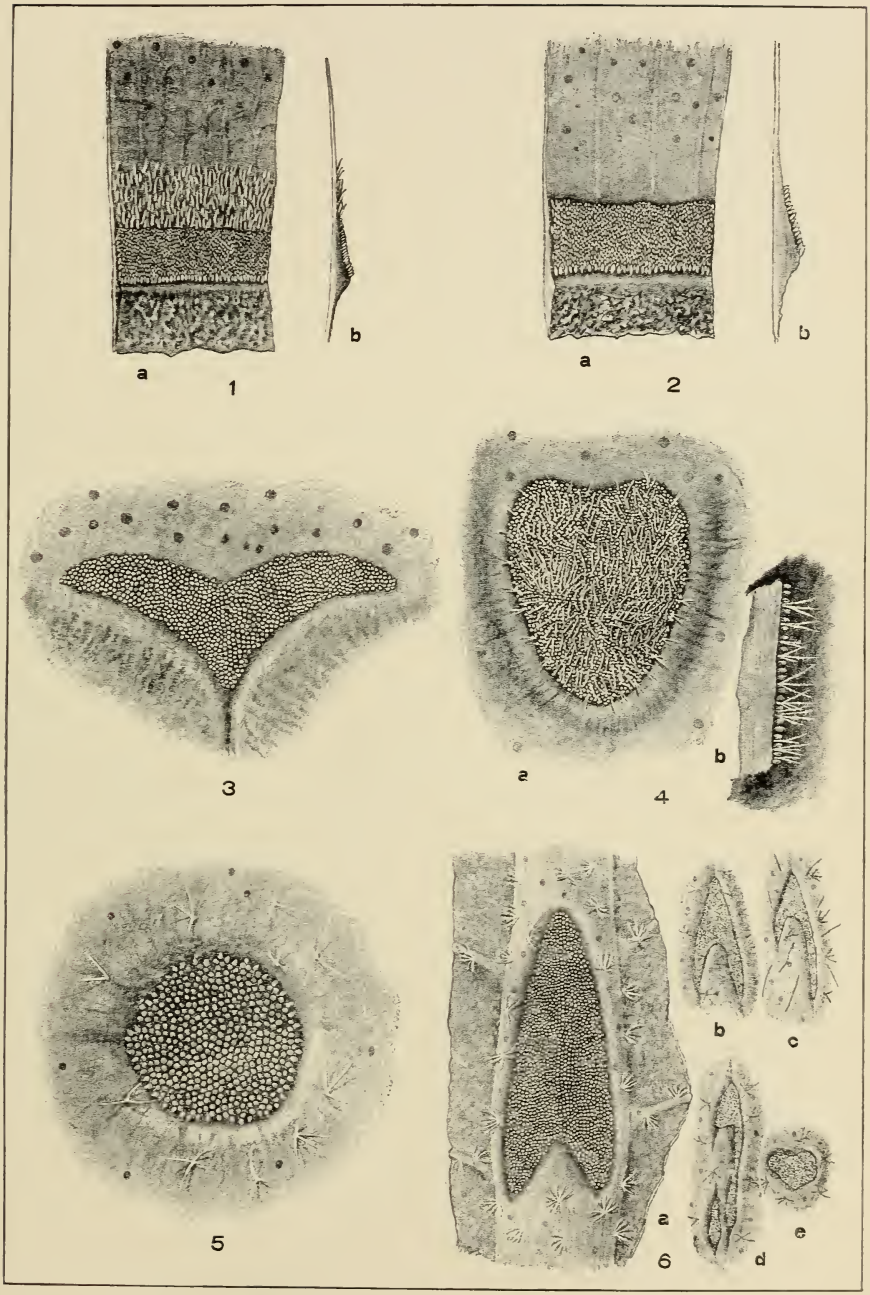
THE LEAF NECTARY.

The leaf nectary (see Pl. I, fig. 6) is located on the under side of the main ribs of the leaf. The glands vary in number from one to

[a] Cook, O. F. Bulletin No. 88, Bureau of Plant Industry, "Weevil-Resisting Adaptations of the Cotton Plant," pp. 30–32. 1906.

[b] Trelease, William, in Comstock's Report upon Cotton Insects, p. 324. 1875.

[c] Watt, Sir George. Wild and Cultivated Cotton Plants of the World, pp. 316–317, pl. 45. 1907.



THE NECTARIES OF COTTON.

five and are often absent in individual leaves, but are perhaps entirely absent in only one species. *Gossypium tomentosum* Nutt. These glands are usually small, rounded, shallow pits, with a floor of round-topped secreting cells. In some species the pit is oval, pear-shaped, or even sagittate, with long tails running down toward the base of the leaf. In the Tropics the leaf glands are soon overrun and blackened by a growth of mold which lives on the secreted nectar.

THE INVOLUCRAL NECTARIES.

The outer involucral glands, three in number, are located at the base of the involucral bracts, on the outside. They are absent entirely in the cultivated cottons of Asia, but are present in all the American species, although not present on every flower. They are usually larger than the leaf glands and form rounded or pear-shaped shallow pits, with a floor of rounded secreting cells. The glands strikingly resemble a shallow, round dish with the bottom covered by a layer of large shot. (See Pl. I, fig. 5.)

The inner involucral nectary (see Pl. I, figs. 3 and 4) also consists of three shallow-pitted glands situated between the calyx and involucre, alternating with the outer glands. This nectary is present in most species of cotton, Asiatic as well as American, though often absent in individual flowers. It is apparently never present in the closely allied genus Ingenhousia, which has been separated from Gossypium on account of the false septa of the ovary. In the Asiatic group of cottons the glands of this nectary are protected by a velvety covering of very short, stellate hairs with erect or ascending branches. (See Pl. I, fig. 4.) This is the more remarkable since the surrounding surface is perfectly glabrous. These glands are naked in all the American species with the exception of a Guatemalan cotton usually considered a form of *Gossypium hirsutum* L., but which is possibly a distinct species. In this case, however, the covering consists of relatively few, very long, branched hairs.

The notes which follow were obtained by the observation of a large number of plants in the field and by examination of the specimens in the herbarium of the United States National Museum and in the Economic Herbarium of the Department of Agriculture. The list of species is incomplete, but all have been included which have been grown by the writer or of which herbarium material could be obtained. In collecting specimens of cotton care should be taken to include several "squares" and buds nearly ready to open, which may be softened and dissected later and the glands studied at leisure.

GROUPS OF SPECIES HAVING SIMILAR NECTARIES.

A. Involucral nectaries both present. American group, also including Bourbon and Scinde cottons.

a. Floral nectary with a band of hairs above.

Gossypium hirsutum L.
Gossypium mexicanum Tod.
Gossypium microcarpum Tod.
Gossypium palmeri Watt.
Gossypium purpurascens Poir.
Gossypium darwinii Watt.
Gossypium stocksii Mast.

b. Floral nectary naked.

Gossypium barbadense L.
Gossypium brasiliense Macf.
Gossypium peruvianum Cav.
Gossypium vitifolium Lam.

B. Outer involucral nectary absent, the inner present, with a covering of stellate hairs. Asiatic group.

Gossypium arboreum L.
Gossypium nanking Meyen.
Gossypium obtusifolium Roxb.
Gossypium herbaceum L.

C. Outer involucral nectary present, the inner absent. Ingenhousia group.

Gossypium davidsonii Kellogg.
Ingenhousia harknessii (Brandegee) Rose.
Ingenhousia triloba Moc. & Sesse.

D. All extrafloral nectaries absent.

Gossypium tomentosum Nutt.

DESCRIPTIONS OF NECTARIES IN EACH SPECIES.

Gossypium hirsutum L. American Upland Cotton.

Leaf glands 1 to 3, usually oval, but often irregular or even sagittate, naked or with a few stellate hairs intruding. (Pl. I, fig. 6, *a*, *d*.)

Outer involucral glands 3, but often one or more wanting, rounded, naked or with a few stellate hairs intruding. (Pl. I, fig. 5.)

Inner involucral glands 3 or less, rounded or oval, naked except in some Guatemalan Upland cottons. These bear a tuft of long, stellate hairs on the gland, the surrounding surface being entirely glabrous.

Floral nectary a zone of papilliform cells with a more or less prominent band of hairs outside. (Pl. I, fig. 1, *a*, *b*.) The Guatemalan and the Dharwar American and other Upland varieties acclimated in India have the band of hairs very strongly developed.

The Moqui cotton and all the commercial varieties of American Upland cottons have the band well developed. This band is apparently always present in the first generation of Upland and Sea Island crosses.

Gossypium mexicanum Tod. Mexican Tree Cotton.

Leaf glands 1 to 3, rounded or ovate slits with swollen sides, or sometimes sagittate with long tails running down toward the base of the leaf, naked.

Outer involucral glands usually 3, narrowly pear-shaped, naked or with stellate hairs intruding from the surrounding surface.

Inner involucral glands usually 3, very broadly V-shaped, naked (Pl. I, fig. 3).

Floral nectary a zone of papilliform cells with a prominent band of hairs outside.

The following cottons belonging to this species were grown and examined: "Cuevas No. 1" and "Cuevas No. 2," from San Luis Soyatlan, Jalisco; "Light's Tree Cotton," from Guadalajara; "Oaxaca," from Oaxaca; "Mexican Tree Cotton," from Mayaguez, Porto Rico.

Gossypium microcarpum Tod., not Watt. Split-Leaved Mexican Tree Cotton.

Leaf glands 1 to 3, usually consisting of narrow slits, naked.

Outer involucral glands 3, narrow, pear-shaped pits, naked.

Inner involucral glands 3, very broadly V-shaped, naked.

Floral nectary a zone of papilliform cells with a prominent band of hairs outside.

The following forms of *Gossypium microcarpum* Tod. have been studied: "Barber's Tree Cotton," from near Matamoras, Tamaulipas, Mexico. "Cuevas Tree Cotton," Nos. 1 and 2, from San Luis Soyatlan, Jalisco, Mexico. The latter were found in seed of *Gossypium mexicanum* Tod. sent from Jalisco by Señor Hilario Cuevas.

Gossypium palmerii Watt. Palmer's Cotton.

Glands very similar to *Gossypium microcarpum* Tod. Seed of this species, which may after all be simply a form of *G. microcarpum* Tod., was obtained from the State of Guerrero, Mexico, and grown under the name "Nolte No. 1." A cotype, N. 184, collected by Dr. Edward Palmer in the vicinity of Acapulco, Mexico, is preserved in the National Herbarium and has also been examined.

Gossypium purpurascens Poir. Bourbon Cotton.

Leaf glands 1 to 3, longitudinal slits or irregular in shape, naked.

Outer involucral glands 3, rounded, naked.

Inner involucral glands 3, rounded-triangular, naked.

Floral nectary a zone of papilliform cells with a very narrow band of hairs above, hardly more than one row.

There is some doubt as to whether the specimen examined, "Spence Tree Cotton," from India, is typical of the above species.

Gossypium darwinii Watt. Galapagos Cotton.

Leaf glands 3, small rounded pits with a few stellate hairs intruding from the surrounding surface.

Outer involucral glands 1 to 3, small rounded pits with a few stellate hairs intruding.

Inner involucral glands 3, low, wide depressions, naked.

Floral nectary a broad zone of papilliform cells with a narrow band of hairs above.

This species, which is related to the *barbadense* group of cottons, is represented in the National Herbarium by a single specimen obtained on Duncan Island, Galapagos, by Alexander Agassiz.

Gossypium stocksii Mast. Scinde Cotton.

Leaf glands obscure or wanting. The leaves are said to be eglandular by Watt,[a] but a large number of the plants must be observed in the field before this point can be decided.

Outer involucral glands 3, consisting of small pear-shaped pits with a few stellate hairs intruding from the surrounding surface.

Inner involucral glands apparently 3, rounded-triangular, the gland as well as entire surrounding surface pubescent with stellate hairs, a character that has been noticed only in one other species, *Gossypium tomentosum* Nutt. Watt[a] states that six small glands are located on the claws of the involucral bracts.

Floral nectary a zone of papilliform cells with a band of hairs above.

A small specimen of *Gossypium stocksii* Mast. is preserved in the National Herbarium. It was collected by Doctor Cooke in Scinde, India.

Gossypium barbadense L. Sea Island Cotton.

Leaf glands 1 to 3, ovate or irregularly sagittate, naked.

Outer involucral glands 1 to 3, often absent, ovate or rounded, naked.

Inner involucral glands usually 3, rounded-triangular, naked.

Floral nectary a zone of papilliform cells without a band of hairs above. (Pl. I, fig. 2, *a*, *b*.)

[a] Watt, Sir George. Wild and Cultivated Cotton Plants of the World, p. 74. 1907.

" Centerville " and " Seabrook " Sea Island cotton have been grown and examined, and the ordinary Sea-Island cotton of James Island, South Carolina, has been carefully studied.

Gossypium brasiliense Macf. (*G. acuminatum* Roxb.) Kidney Cotton.

Leaf glands 1 to 3, large, usually sagittate, naked or with stellate hairs intruding from the surrounding surface. (Pl. I, fig. 6, *b*, *c*.)

Outer involucral glands usually 3, but often one or more absent, quite large, rounded, naked.

Inner involucral glands usually 3, but sometimes absent entirely, rounded very shallow depressions, naked.

Floral nectary a zone of papilliform cells only.

The following Kidney cottons were grown and examined: " Panuco River," from Tamos, Veracruz, Mexico; " Togoland," from West Africa; " Kafir Kidney," from the Transvaal; " Samar Island," from the Philippines.

Gossypium peruvianum Cav. Peruvian Cotton.

Leaf glands 1 to 3, oval, triangular or sagittate, naked.

Outer involucral glands 3 or less, quite large, rounded pits, naked.

Inner involucral glands 3 or less, oval, naked.

Floral nectary a zone of papilliform cells only.

Seed of this species was obtained from Peru, labeled " Peruvian, Full Rough Catacaos," and was grown in Florida. The annual Egyptian cottons, Ashmuni, Jannovitch, Mit Afifi, etc., have also been grown and studied. Their botanical classification is uncertain, being placed in this species by Doctor Watt, but by many considered forms of *Gossypium barbadense* L. Their floral nectary differs from either in that it has a narrow band of hairs above the papilliform zone.

Gossypium vitifolium Lam. Vine-Leaved Cotton.

So far as can be seen from herbarium specimens the nectaries of this species are similar to those of *Gossypium peruvianum* Cav.

Gossypium arboreum L. Purple-Flowered Tree Cotton.

Leaf glands 1 to 3, usually pear-shaped or irregular, naked.

Outer involucral glands absent.

Inner involucral glands 3, quite large, rounded-triangular or shield-shaped, densely covered by a velvety mass of stellate hairs. (Pl. I, fig. 4, *a*, *b*.)

Floral nectary a zone of papilliform cells only.

The following cottons belonging to this species have been grown and observed: " Narma Bari," from the Saharanpur Botanic Garden,

Saharanpur, India; "Dev Kapas," "Pamidi parutti," etc., from Prof. G. A. Gammie, Poona, Bombay, India; "Siamese Tree Cotton," from Siam.

Gossypium arboreum sanguineum Watt. (*G. sanguineum* Hassk.). Red-Flowered Annual Cotton.

The nectaries are similar to those of *Gossypium arboreum* L.

Seed of "Bagar Siah," a cultivated form of this variety, was obtained from Professor Gammie, of Poona, and grown at Auburn, Ala.

Gossypium arboreum assamicum Watt. (*G. cernuum* Tod.). Assam Cotton.

Nectaries similar to those of *Gossypium arboreum* L.

Seed of several named races of this cotton were obtained from Professor Gammie, of Poona, and also a form known as "Garo," from the Garo Hills, India. Part of these were grown at Auburn, Ala., and at Waco, Tex.

Gossypium arboreum neglectum Watt. (*G. neglectum* Tod.). Bengal Cotton.

Nectaries similar to those of *Gossypium arboreum* L.

Seed of two forms of this species, "Japan Wool" and "Buriah Kapas," from the Louisiana State Experiment Station, Audubon Park, La., and a large number of named varieties from Poona, India, were grown at Auburn, Ala.

Gossypium nanking Meyen. (*G. indicum* Lam.). Chinese Cotton.

Leaf glands 1 to 3, small, oval, or irregular, naked. (Pl. 1. fig. 6, *c*.)

Outer involucral glands absent.

Inner involucral glands 3, large, rounded-triangular or shield-shaped, with a covering of short, stellate hairs.

Floral nectary a zone of papilliform cells, naked or sometimes with a very narrow band of hairs outside.

Seed of this species was obtained from Japan under the names "Kawasaki," "Murasaki," "Akaki," and "Aoki"; from southern Russia under the name "Transcaucasian," and from Korea. A number of named races were obtained from Professor Gammie, of Poona, India.

Gossypium nanking bani Watt. Bani Cotton.

Nectaries similar to *Gossypium nanking* Meyen.

Forms of this variety were obtained from Director D. Prain, Calcutta Botanic Gardens, Sibpur, India, labeled "Common country cotton of India" and "Garo Hills."[a] The latter was often almost

[a] Watt, Sir George. Wild and Cultivated Cotton Plants of India, pp. 118–124. 1907.

glandless except that the floral nectary was always present. It should not be confused with the true Garo or Garo Hills cotton, a form of *Gossypium arboreum assamicum* Watt.

Gossypium obtusifolium Roxb. Ceylon Cotton.

Leaf glands 1 to 3, small, oval or irregular, naked.

Outer involucral glands absent.

Inner involucral glands 3, rounded-triangular in shape, with a covering of short stellate hairs.

Floral nectary a narrow zone of papilliform cells only.

Seed of this species was obtained from the Royal Botanic Garden, Ceylon, and grown in Texas.

Gossypium obtusifolium wightianum Watt. (*G. wightianum* Tod.). Gujarat Cotton.

Nectaries similar to *Gossypium obtusifolium* Roxb.

Seed of several Gujarat cottons belonging to this variety were received from Professor Gammie, of Poona, and grown at Auburn, Ala.

Gossypium herbaceum L. Levant Cotton.

Leaf glands 1 to 3, nearly round or often deltoid in shape, naked or with occasionally a few stellate hairs intruding from the surrounding surface.

Outer involucral glands absent.

Inner involucral glands 3, large, rounded-triangular or shield-shaped, with a covering of short stellate hairs.

Floral nectary a zone of papilliform cells only.

This species, which can hardly be distinguished from many of the forms of *Gossypium obtusifolium*, was grown from seed obtained from Aidin, Smyrna, and from Malta.

Gossypium davidsonii Kellogg. Davidson's Cotton.

Leaf glands 1, small, rounded or pear-shaped, naked, very close to the base of the blade.

Outer involucral glands 3, very small, rounded pits, naked or with stellate hairs intruding.

Inner involucral glands absent.

Floral nectary a zone of papilliform cells with a rather narrow band of hairs outside.

This cotton is intermediate between Gossypium and the closely related genus Ingenhousia, two species of which are included later for the purpose of comparison. As far as can be seen from the herbarium specimens examined, it is similar in seed characters and nectaries to Ingenhousia, but lacks the false septa of the ovary which

characterize that genus. The bracts of the involucre and leaves resemble more closely those of Gossypium. The seed characters of this group are remarkable. The lint or fuzz appears to be entirely absent, but when examined with a lens there is seen to be a very short, minute fuzz, which is plastered close to the surface of the seed.

Specimens of Davidson's cotton from Guaymas, Mexico, from Magdalena Island, and from Cape St. Lucas, Lower California, are preserved in the National Herbarium.

Ingenhousia harknessii (Brandegee) Rose in Herb. (*Gossypium harknessii* (Brandegee).[a]

Leaf glands 1, a very small rounded or pear-shaped pit, very near the base of the leaf.

Outer involucral glands 3, rounded pits reddish brown in color, naked.

Inner involucral glands absent.

Floral nectary a zone of papilliform cells with a narrow band of hairs.

The National Herbarium contains specimens of this plant collected by Dr. Edward Palmer on Carmen Island, Mexico.

Ingenhousia triloba Moc. & Sesse. (*Thurberia thespesioides* Gray.)

Leaf gland 1, a narrow slit with swollen sides, situated very close to the base of the leaf, reddish brown in color, naked.

Outer involucral glands 3, rounded, quite prominent pits.

Inner involucral glands absent.

Floral nectary a zone of papilliform cells with a prominent band of hairs outside.

Numerous specimens of this plant collected in Arizona and Chihuahua are preserved in the National Herbarium.

Gossypium tomentosum Nutt. Hawaiian Cotton.

Leaf glands absent.

Outer involucral glands absent.

Inner involucral glands absent.

Floral nectary a prominent zone of papilliform cells and a narrow band of hairs outside.

Seed and bolls of this variety were obtained from the islands of Oahu and Molokai, Hawaii, and plants were grown in Texas and in the greenhouse at Washington, D. C.

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[a] Brandegee, T. S. Plants of Baja California. Proceedings California Academy of Science, 2d ser., vol. 2, pp. 136–137. 1889.

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